TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. VI No. 3. MARCH, 1929. PRICE 6d.

CONTENTS.

	PAGE.
Tropical Forest Lands	65
Colonial Appointments	67
West Indian Grapefruit..	67
St. Lucia Banana Lands	69
Rainfall and Crop Conditions (*Concluded*)	74
Yellow Fever in Africa	77
Nursery Work (*Concluded*)	78
A Parasite "Zoo"	80
Vitamins (*To be continued*)	81
Agriculture in Ceylon	83
Tropical World Notes	84
Budded Rubber	86
Chemical Notes	87
Sugar Notes	88
Reviews	89
College News	90
Sir James Currie's Visit..	91
Agricultural Excursions	91
Gift to Sugar Factory	91
Biological Excursions	91
Trend of the Markets	92

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 1983.

TROPICAL AGRICULTURE is published at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies, at the end of the third week of the month preceding the one of issue. Advertisement rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed in signed articles are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

TROPICAL FOREST LANDS.

SO MUCH has been written about the presumed natural high fertility of tropical forest soils, that it might be well at this stage in the rapid development of many tropical regions, to inquire into the reasons which may or may not justify the general acceptance of the idea. There have been many instances of disappointment following attempts on the part of settlers in tropical countries to bring humid virgin soils into successful cultivation for certain crops. Things have gone very well for a few years, and then a rapid diminution in productiveness has been experienced. Mr. E. A. Walters ably discusses a particularly interesting case in his article appearing in the current issue of this Journal. He has described how the forest lands of St. Lucia in the British West Indies have given very unsatisfactory results when utilized for banana growing. He attributes failure to the profound changes that have occurred in these lands since the ancient forest covering was removed. He stresses the concomittant adverse effects caused by surface erosion which leads to loss of soil organic matter, and by reduction of wind belts which results in loss of soil moisture. Anyone conversant with the agricultural development of humid tropical countries could doubtless quote similar instances of soil degradation following land exploitation.

It is not generally realized that many tropical forest soils, despite their superficial appearance of high fertility, are deficient in plant nutrients. Some years ago, the late Sir John Harrison wrote as follows about the forest soils of British Guiana.

> "The question has been raised as to how it is possible for the British Guiana soils, if they are so lacking in fertility as appears from chemical analysis, to support as they do, a heavy forest growth. In the case of a forest, the nutrient constituents of plant food are taken up by roots which traverse a very wide area. In that of cultivated plants, the space occupied by the roots is comparatively small. Hence the trees can draw their necessary food from a relatively enormous mass of soil compared with that which the cultivated plants can utilize. The mineral constituents in the case of trees, accumulate in the leaves and in the small branchlets, but little being retained in the wood of the

stem. When the leaves are shed, the mineral substances are returned to the soil. Similarly, a considerable proportion of the plant food is, in the case of certain trees, returned by fallen flowers. The plant food thus returned to the soil from which it was derived, is set free by decomposition, and is again utilized by the trees. Thus it may be described as circulating and performing its functions in a practically endless circuit from soil, through the tree to its leaves and flowers, and back to the soil. The tendency in the forest is for much of the plant food gathered by the deeper roots to accumulate in the upper layers of the soil. In our tropical forest, this has taken place in the course of ages to such an extent that the trees which now flourish therein are largely surface feeders so that their roots spread through the thin layers of vegetable débris on the surface soil in a widely extending plexus."

"With the majority of cultivated plants, the constituents of the manurial plant food are largely removed in the products, and are thus lost to future generations of plants raised on the same soil. Hence soils capable of supporting a long continued forest growth may, and as repeated experience during recent years has amply proved, do, when under economic cultivation, fail after very few seasons to produce crops of any value."

"Further, forest trees appear to flourish on soil solutions of far lower salt contents than the majority of plants of economic value can do, and it is a matter of interest to ascertain if this power of utilizing soil solutions of greater diluteness may not be due to the trees growing in symbiosis with some of the fungal organisms with which the upper layers of our forest soils teem."

Dr. Ramann, the famous German soil scientist, puts the same conclusions very aptly when he writes: "The tropical forest works with a small capital of nutrients and a rapid turnover," so that "a small amount of nutrient circulating quickly, suffices for the maintenance of luxuriant vegetative growth."

There is urgent need at the present time for detailed investigation into the genesis and evolution of humid tropical forest soils, and of the effects of man's interference with the natural processes that have given rise to them. In recent years, extensive study has been made of the part played by climate in the evolution of soils. So far, however, the work has been confined mainly to temperate and sub-tropical regions, notably Russia, Germany and the United States of America. The most comprehensive statement of the principles of this new branch of soil science is due to the Russian investigators. Their generalizations are now being assiduously tested and applied in the United States, and to a lesser extent, in Great Britain.

The scientific investigation of tropical soils has only just begun. Until considerable headway has been made, it is more than likely that wasteful and unremunerative exploitation of virgin tropical land will continue unabated, and that many further mistakes will be made. It is not sufficient merely to apply the results of accumulated knowledge of the properties and behaviour of well-established cultivated arable soils. It would indeed be entirely futile to do so, for, whereas in cultivated agricultural soil the components of the soil proper have been more or less thoroughly mixed by repeated tilling, natural undisturbed soil shows a gradual transition from the surface downwards, often over a considerable distance. There is no distinct subsoil, and the natural vegetation pushes its roots to different depths depending on its botanical composition. Thus, some of the vegetation may be rooted exclusively in the surface layer of leaf debris, whilst other species may have their root systems developed in underlying soil strata, or even in the parent material itself.

It is evident that an entirely new technique will have to be elaborated for the examination of undisturbed tropical forest soils, and that experimental areas will have to be studied in detail before any general rules can be formulated for their successful utilization in agriculture. Different districts will have to be taken entirely on their merits, always with the view-point of their adaptability or otherwise to the growing of any specific crop.

It is from this aspect that a study of tropical forest soils has recently been inaugurated at the Imperial College of Tropical Agriculture. So far, the work has been confined mainly to old established cacao lands in Trinidad. These comprise forest regions that have been adapted to the growth of cacao under tree shade with little disturbance of the original soil beyond that caused by the construction of surface drains. Areas of different ages with reference to the time when they were first planted in cacao are being compared between themselves and with adjacent areas still under virgin forest. Further comparison with areas that were once under cacao and are now growing sugar-cane is possible, and may form a continuation of the present investigation.

The method of soil examination consists in the laboratory study of soil samples obtained at different depths from the surface in holes specially dug at selected sites. The profiles exhibited by the sections are descibed; their natural differentiation into conspicuous strata is noted; the thickness of each of these strata is measured, and finally, soil samples representative of the individual layers are procured. In the laboratory, quantitative determinations of such factors as degree of acidity or of alkalinity, content of soil organic matter and of humus,

mechanical composition, concentration of total and specific soil nutrients and calcium carbonate content are made on each of the samples of soil.

Trinidad appears to be especially suitable for studies such as these, because of its diversified geological structure, its varied topography and its unequal rainfall distribution. The number of different soil types presented therein is quite large; they range from mature sedentary soils to recent swamp and stream alluvium. A considerable proportion of the land is still agriculturally undeveloped, and several forest reserves have been demarcated both in the uplands and in the plains.

From the biological aspect, much work requires to be done on the identity and activity of various organisms that comprise the soil flora and fauna. The question of microbial nitrogen transformations in tropical forest soils is almost untouched. The possibility of tropical forest trees utilizing symbiotic mycorrhiza as absorbing organs for obtaining supplies of different nutrients, is worthy of careful study. The form in which the trees obtain nitrogenous nutriment, whether it be ammonium compounds or nitrates, and whether or no the reaction of the soil environment plays a part in this relationship, still remain to be elucidated. Some information on these subjects has been accumulated for temperate forest soils, but it does not necessarily follow that this knowledge can be applied without qualification to humid tropical conditions.

Only when an accurate understanding of the genesis, composition and nutrient status of tropical forest soils has been acquired can one hope to be able to assess the potentialities of any particular tropical forest area, to predict what is likely to happen when the forest covering is removed, and to prescribe ultimate tillage and manurial treatments requisite for the formation of new types of soil suitable for the cultivation of remunerative crops.

To proceed with the wholesale exploitation of our tropical forest lands without at least an appreciation of these fundamental problems is to court disaster, if not wantonly to waste one of Nature's greatest gifts.

COLONIAL APPOINTMENTS.

THE following appointments and transfers have been made by the Secretary of State for the Colonies during the month of December, 1928.

Mr. K. R. S. Morris, B.SC., A.R.C.S., Assistant Entomologist, Gold Coast.

Mr. M. Vardy, Manager, Experimental Fruit Farm, Sierra Leone.

Mr. E. Messervy, M.R.C.V.S., Veterinary Officer, Tanganyika Territory.

Mr. H. M. Gardner (Senior Assistant Conservator of Forests, Kenya), Conservator of Forests, Kenya.

Mr. L. P. Henderson (Agricultural Instructor, Federated Malay States), Superintendent, Agricultural Department, Nigeria.

Mr. G. N. Sale (Assistant Conservator of Forests, Cyprus) Director of Forests, Mauritius.

Mr. C. L. Southall (Government Chemist, Fiji) Assistant Analyst, Straits Settlements.

WEST INDIAN GRAPEFRUIT.

GRAPEFRUIT CULTURE IN THE BRITISH WEST INDIES AND BRITISH HONDURAS. By Professor H. Clark Powell, B.SC., Professor of Horticulture, Transvaal University College, Pretoria. Empire Marketing Board Publication, E.M.B. 13. *H. M. Stationery Office*, London, Decr. 1928. Price 1*s*. 0*d*. net.

It is explained by Sir Edward Davson in a preface to this report that on receipt of applications from certain Colonies for financial assistance in developing citrus fruit cultivation and export, the Empire Marketing Board felt the need for a general review of the prospects of citrus production in the Colonial Empire. Accordingly, in August, 1927, the Board invited Professor H. Clark Powell, Professor of Horticulture at the Transvaal University College, and Technical Adviser to the South African Co-operative Citrus Exchange, to investigate the problems relating to citrus fruit cultivation in various Empire countries. He first visited Palestine, Cyprus and Zanzibar, then California, Florida, British Honduras and the West Indies. The present report, dealing with the last two regions, is of considerable importance to them as a discussion of the prospects of what may prove to be a very profitable alternative or additional industry.

Professor Clark Powell starts with the economic aspect, and points out that the main hope of the West Indies in grapefruit culture lies in their lower costs of production. The industry is not yet stabilised, and both production and consumption are increasing very rapidly every year. This alone would indicate that further expansion of production would be a highly speculative procedure, but at present the West Indies can land and sell fruit either in the United Kingdom or in Canada at a figure substantially lower than can any of the American producing areas. The difference is due to rainfall which eliminates the cost of irrigation, soil differences which reduce the cost of fertilizing, lower cost of land, and cheaper pest control, and so long as these conditions obtain the West Indies and British Honduras need not fear the possibility of over-production by their larger competitors. They must, however, be prepared to compete in quality as well as in price, and this involves the utmost care in grading and packing.

Since the existing publications on citrus fruit culture apply almost exclusively to countries where conditions are quite different from those of the West Indies, Professor Clark Powell devotes the rest of his paper mainly to setting down conclusions based on his observations of the local conditions, with the object of providing for the prospective West Indian grapefruit planter some preliminary guide to procedure, which can be modified as experimental work and further experience of planters and Departments of Agriculture may indicate in the future.

The best sites for first development are those with a fertile soil of medium texture, well-drained, and at least two feet deep, a rainfall of about

75 to 100 inches, well distributed, and a position easy of access from the point of export, since it is of the first importance that mechanical injury to the fruit in transit be avoided.

Detailed notes are given on planting, and especial emphasis is laid on the importance of careful selection of the planting material, both stocks and buds. With respect to the latter it is pointed out that on account of bud mutations, which are frequent in grapefruit, a grove of one variety such as Marsh always contains a proportion of undesirable trees, and unless the trees from which budwood is to be taken are selected with the greatest care, as trees which are known to bear well and to bear only fruit of the desired type in every respect, there is serious risk of propagating an increased proportion of undesirable types. Stocks, being seedlings, are to be expected to vary, and in the absence of detailed knowledge of the full extent of the variation, the planter is advised to give particular attention to size differences in stocks, and to bud only on the largest in the nursery rows. A great deal of the size difference between stocks is held to be genetic in nature, and scions budded on inherently small and slow growing stocks will always be smaller and less productive under similar conditions than those budded on the more rapidly growing stocks. This argument is pointed by photographs, reproduced on page xiv in this Journal, of two groves in California, where a difference of 15 cents in the original cost of the trees is reflected in a marked difference in size at the same age several years later.

On this follows a discussion of nursery practice, and the sour orange is recommended as a stock, pending further investigation of the whole question, in which all the various stocks possible and likely to give good results should be tried out experimentally. Care of the seedbeds and nursery beds is described, and the budding operation, which should be done at ten inches from the ground, in order to keep the union and the susceptible grapefruit wood away from ground level and the danger of collar rot. Budded plants should be staked, and headed at 30 to 32 inches from the ground, after which four to six scaffold branches should be allowed to develop, well distributed round the trunk. A good tree cannot be produced in this manner at a cost of less than two shillings, and it is again emphasised that within reasonable limits the original cost of the nursery stock is immaterial, and the planter should insist on the best trees it is possible to produce, and on no account prejudice the future of his grove in an attempt to save a few pence on planting material. Young trees need continual attention, and the planter should himself inspect every tree at least once in two months. If a tree is properly trained from the time it is planted, a great deal of cutting of large branches, with consequent damage to the tree, can be avoided later.

It is in the cultivation and care of the established grove that West Indian methods are likely to differ most markedly from those adopted in most of the countries at present producing citrus fruits on a large scale. In those countries the crop is chiefly grown under semi-arid conditions, and often in very light sandy soils which need continual and heavy fertilization. Methods of clean cultivation adopted under such conditions are not necessarily the best under conditions of high rainfall and heavier soils, but rather are open to serious objection. Professor Clark Powell does not dogmatize on the subject, but he is in favour of growing either a natural weed cover, or, if it be found in practice more desirable, a leguminous crop such as *Tephrosia* between the trees, to be cut at regular intervals and used as a mulch. A very definite warning is appended that whatever cover is used must be kept under proper control. On no account must weed growth be allowed to interfere with the development of the trees, and in all cases and at all ages of the trees the ground must be kept quite clean for at least a foot round the base of the trunks.

In the maintenance of an established plantation at a maximum productivity, the use of individual tree records is indicated. It is suggested that each tree should be classified according to its fruit production into one or other of five grades. When this has been done for four years a map is made on which the trees falling consistently into the two highest grades are marked as profitable, and those in the two lowest grades as unprofitable. The middle class contains trees which just pay for their keep. Inspection of such a map can teach the planter much. Where whole groups of trees are seen to be poor bearers, the reason is to be sought in some environmental factor, which must be determined and dealt with appropriately. On the other hand, where isolated trees are unproductive, the reason is likely to be inherent, and such trees are better removed, unless the defect is one which can be cured by top-working.

The report closes with remarks on picking and packing. The need for the greatest care in these operations to minimize injury to fruit, with consequent decay in transit to the markets, is well stressed, and the precautions to be observed are mentioned. Uniformity is to be attained by planting throughout the region not more than two varieties—Marsh and Duncan are recommended—and maintained by grading. It is recommended that each island should ship two grades—extra choice and standard—under two distinct brands, as thus uniformity of grading would be established, yet the fruit of each island would stand on its own merits.

Appended are brief notes on the present position and prospects with regard to grape fruit production of the Bahamas, British Honduras, Dominica, Grenada, Jamaica, St. Lucia and Trinidad.

It is hoped that the above brief outline of its contents will serve to indicate the usefulness of this Empire Marketing Board publication to West Indian grapefruit growers, present and potential.

E. E. Cheesman.

WEST INDIAN GRAPEFRUIT

(*See* p. 67.)

All photographs appearing in this issue were taken on behalf of the Empire Marketing Board and have been reproduced by the kind permission of the Controller, His Majesty's Stationery Office, London.

Figure 1. A five-year old grove in Trinidad, showing deep surface drains. The rainfall on this site averages 110 inches per year and the soil is heavy.

Figure 2.—Grove X, Strathmore, California.

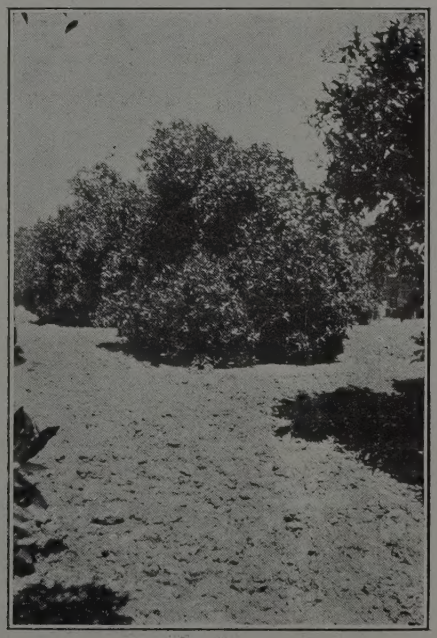


Figure 3—Grove Y, Strathmore, California.

WEST INDIAN GRAPEFRUIT.

Figure 4.—A nursery in Florida, illustrating the method of training the young trees.

Figure 5.—A grapefruit tree recently planted. It had no training in the nursery and on planting in the field should have been staked. Compare with the trees shown in Fig. 4.

ST. LUCIA BANANA LANDS.

Observations and comments on Soil Changes in relation to Tropical Agriculture.

BY E. A. WALTERS, F.R.H.S., F.R.Met.Soc.,
Agricultural Superintendent.

THE present paper records soil changes observed when virgin forest land is subjected to exposure and climatic influences by removal of the natural vegetation and by the substitution of a temporary crop [1], followed by a final re-invasion of a low type of flora.

As a generalisation which holds true for most tropical countries, it may be said that tropical agriculture falls into two fairly well defined categories—in the first, definite agricultural operations, such as tillage, fertilising, and soil improvement, are undertaken, while in the second category methods of clearing virgin forest and cropping with the minimum of cultivation necessary to plant and raise the crops are adopted, such as the firing of bush for planting roots, the digging of holes for root stocks which are merely covered with a layer of soil, and the annual brushing of weeds in established crops. Examples of both classes are of frequent occurrence in the West Indies and Central America. According to the methods pursued different kinds of biological processes will be set in motion which may ultimately become of very great agricultural significance [2]. In short, the soil will either undergo progressive amelioration or progressive deterioration.

The writer has seen virgin land cleared for large-scale banana production, the raising of banana crops, the ultimate collapse of the industry, the withdrawal of all supervision from cultivated areas, followed by the re-establishment of a natural flora. Careful observations have been made over a period of five years, on the original soil conditions and its plant population, the exploitation of this soil under banana cultivation (which it should be noted falls into the second category as above) with a concluding survey of the present state of the soil in derelict banana lands. These observations have shown that there are certain important influences which will affect tropical agriculture conducted along these lines.

Opening of banana lands.

The Banana Company was probably the first to clear large areas of virgin forest in St. Lucia for a pure crop. New tracts of land had, in the main, been taken up cautiously and planted tentatively in a short period crop such as sugar-cane, which as a pioneer crop was utilised to break up the soil and promote a superficial tilth. One, or sometimes two of the long period crops such as coconuts, cocoa or limes, usually followed in the second or third year, with plantings of bananas and other accessory crops.

There was thus little available information as to the changes resulting from the removal of the heavy and ancient forest vegetation and its substitution by a comparatively light crop such as bananas. It is interesting to note that the large-scale physical effects occasioned by the loss of the protective forest canopy began to be obvious within two years from the removal of the forest, and took the form of land slides and eroded surfaces. Similar, but more intensified conditions have been recently reported by Hill as appearing in Jamaica, [3] following the replacement of forests by coffee plantations. In view of these and other instances such defects cannot be regarded as accidental but predetermined, given the coincident factors of soil formation, declivity and rainfall, with the absence of protective vegetation.

The apparent reason for the selection of forest land was the belief that it was naturally fertile and had a fairly high rainfall; there was the additional advantage that an extensive area was available for development.

Topography of banana country and climatic conditions.

The elevation of the site selected for banana cultivation was 400 ft. above sea level, in a mountainous and broken region at the foot of Mt. Lacombe, a peak over 1,480 ft. high, arising from the central ridge and water-shed of the Colony. The land in this area consists of a series of moderately steep slopes lying at angles of 25° to 45° mostly facing west and north and forming the foot of the central ridge. In the upper areas these slopes end in abrupt banks enclosing small streams and forming shallow embryo cañons, which on lower levels widen out and expose the underlying igneous rocks forming the bed of the stream. These wider river valleys appear to be an advanced stable stage of the cañon-like formations still found in the upper areas, and represent the continued erosive action of rainfall and streams in washing out the soil in the upper and middle areas and generally smoothing down the projecting land masses. Much of the soil so removed has been transported down stream and has formed to some extent the larger and fertile alluvial valleys near the sea.

The upper lands around the sources of the cañon-like streams have not yet been smoothed out, owing largely to the protective effect of the forest canopy in reducing erosion. They show no rocks or consolidated material, and where exposed by removal of the forest trees, rapidly scour away and form landslides, which precipitate the surface soil into the streams and carry it into the lower valleys. Such lands are naturally in a state of instability owing to the effect of erosion and climatic stress, and these effects are greatly accelerated by the removal of the forest canopy. One purpose of this paper is to point out how the soil is degraded and agricultural operations are interfered with, unless means are taken to consolidate the soil *in situ* before degradation has progressed too far.

The banana lands lie within a yearly rainfall contour of 100 inches, the maximum precipitation being from 4 to 5 inches in one day. High winds

are usual during rain storms and in combination with the rain drops produce a drilling effect on the exposed soil, which being of a clayey nature soon becomes water logged and insecure on its bedding of weathered soft rocks.

The fairly wide range of air temperature (from 62° to 88°) which obtains in this region is an important factor in promoting denudation of exposed sites. In the forest, however, the range is less, the maximum temperature being depressed by the heavy shade and constant high humidity. An effect of this buffer action is to reduce evaporation and retard the upward movement of soil water. When the forest vegetation is removed other factors come into play to promote desiccation, the chief of these being the absence of transpired water vapour, the depression of humidity, the formation of drier air currents, and an increased range of temperature, due to exposure to the direct rays of the sun. These factors combined with direct rainfall tend rapidly to remove the accumulated humus which is not replaced by natural agencies until a crop is established or some form of vegetation covers the soil.

Soil and flora of virgin forest.

(*a*) *Soil.*

The soil of this region consists of weathered volcanic matter derived from the washings and denuded material of the igneous agglomerates, tufas, brecchias and grits, which have decomposed in the direction of hydrated silicates of aluminum, iron, and magnesium. ([4]) The soil profile is thus influenced to a great extent both in colouring and texture by the presence of these elements, and shows all gradations from a yellowish to bright red lateritic clay on the surface to a varicoloured kaolinized soft rock or soapstone below. As mentioned before no surface rock is present and where the underlying decomposed rock is exposed as in road cuttings or landslides, it quickly breaks up into granular fragments in which iron oxide is conspicuous, and is thus added to the soil. The absence of gravels and rock fragments in this type of soil renders natural drainage defective and this is to some extent responsible for the peculiar changes mentioned below which follow deforestation.

(*b*) *Flora.*

The vegetation of this region is of the tropical rain forest type, and has reached a stage of dominance and comparative stability (forest climax) until artificial agencies (biotic factors) intervene. ([5]) These include selective felling and general removal of timber for agricultural development. So far as can be observed no natural afforestation takes place once the climax forest is removed, and the reason is probably to be sought in subsequent soil and climatic changes. The rain forest is composed of three well defined strata of vegetation, the upper, forming a fairly dense canopy at about 80 to 100 ft. above the ground, and consisting mainly of solitary specimens of Balata, Courbaril, *Inga*, *Andira* and *Richeria*, above which rise the loftier forms such as *Sloanea*, *Nectandra* and *Bursera*. Below the canopy is a sub-stratum of short trees and tall shrubs including several palms, viz.: *Asclepias*, *Clavija*, *Thrinax* and *Acrocomia*; this is discontinuous and varies according to light intensity and exposure. The ground vegetation consists of short shrubs and creeping herbs, the latter only being conspicuous where the light is more intense.

The absence of any form of close growing surface vegetation on the forest floor, such as mosses, dwarf ferns, &c., is interesting in view of the strong succession of herbs which invades an area cleared from forest. It may be due to some extent to the absence of light, although the forest bryophytes generally have but a poor light requirement. It is probable that a more definitely inhibiting factor is the loose mass of slowly decaying vegetable matter which accumulates on the undisturbed forest floor to a depth of from two to three feet in the absence of sunlight or other desiccating agencies. This layer of "raw humus" resembles the Hochmoor peat formations, typical examples of which have been found in St. Lucia in undrained low-lying land under cultivation where remains of a buried forest flora still exist in a fairly well preserved state.

Soil conditions at time of planting.

Two main soil types will be taken as instances conforming to general conditions observed at the time of planting bananas. Soil type No. 1 was observed in planting the nursery in 1923 and soil type No. 2 in planting the hill slopes of new areas opened up in 1926. Soil type No. 1 found in the site described as the nursery in this and a former paper ([1]), was part of the first area of forest land exploited by the Banana Company. The site consisted of about 200 acres of forest land lying along the north-western slope of a moderately steep ridge running out from the foot of the central peak previously mentioned, and was more exposed to the prevailing winds than land described under soil type No. 2.

The soil consisted of a brownish-yellow clay loam and was typical of the forest soils in their area. It was covered by a loose layer of forest litter, the original deposit of which had apparently decayed and brought about a definite colour and texture change in the first three to six inches of soil immediately underlying it. The top layer was distinctly darker and looser than the subsurface soil. At twelve inches the latter was a brownish-yellow smooth clay loam becoming more compact and tenacious as depth increased. Only the stronger primary roots of forest trees appeared to penetrate more than two feet, the principal root section being the first 18inches as seen in the root profiles taken in this area. The soil puddled readily in wet weather but responded to aeration and liming by changing in colour from brownish-yellow to brownish-grey

and by forming a definite crumb structure, a change observed in the strictly localised spots where bananas had been removed and the soil limed.

Soil type No. 2 found on the westward slopes of Mt. Lacombe (previously under forest) was not exposed to the prevailing winds as was No. 1. Its characteristics differed from the former by being apparently less weathered, and with less admixture of humus, while the forest litter was rather more matted and overlaid a shallow root stratum. The soil was a yellow clay showing little differentiation with depth and in its general character appeared to be an earlier stage of soil type No. 1. This soil became very sticky in wet weather and was naturally retentive and difficult to work; no observations on liming were made as no lime was applied at any time; the effect of aeration was temporarily to granulate the soil in large particles, but these broke up again when the soil became saturated.

Method of cultivation practised on banana lands.

It now falls to discuss how these soils were treated and the nature of their response. In the first place the object of growing bananas in the forest lands was to take advantage of the fertile soil and of the moderately large areas available, so that planting and cropping could alternate without a break in fruit supplies. It is thus readily understood that sites found to be unproductive would be abandoned for new land taken from the forest, rather than an attempt being made to bring the unproductive soils into bearing. A further inducement was found in the presence of Panama disease of bananas, although this disease was not confined to the unsuitable types of soil. The type of cultivation practised thus falls within the second category mentioned at the beginning of this paper.

The method of treating the forest land preparatory to planting bananas consisted of felling the forest trees, and burning or moving aside the larger logs where these interfered with planting operations. The ground was then cleared of the remaining bush and holed ready for the banana plants. Contour drains were cut along the slopes to take off the surface water, and in some areas the banks of soil thrown up were levelled and planted with a legume, *Canavalia ensiformis*.

Forking and trenching was not practised as part of the cultivation programme and no manures were incorporated in the soil, as it was considered that sufficient organic matter would be supplied by the decay of forest logs. The application of lime was solely intended for destroying the chopped remains of diseased bananas.

Cultivation was thus a matter of direct exploitation and as elsewhere the first returns of the crop were sufficiently good to endorse this practice. The subsequent and rapid degradation of the soil goes to show, however, that the initial crop production was not a true index of the staying fertility of these lands when subject to intensive cropping. The latter could only continue in the presence of some natural agency which would replace the utilised plant-food and humus. In the absence of such safeguards, the regression of the fertility of the forest soil must be regarded as a natural consequence.

Progress and termination of banana planting.

The method pursued in the earliest stages consisted of clearing and planting a stretch of land in bananas without discrimination as to soil types. It was soon found, however, that certain areas were unproductive, and the conclusion was drawn by comparison of earlier sites with present remains of cultivated areas that these unproductive soils had already been exposed and were already in a state of deterioration at the time of planting. As similar conditions can now be seen in large sections of banana fields attention may be drawn to the fact that the succeeding stages of exposed forest land can be roughly foretold by an examination of adjoining forest lands which have been subjected to intermittent cultivation without the modifying effects of cover crops and windbreaks.

The decision to end the banana industry was due to the want of capital to complete marketing arrangements and not to insufficient production. It should be added that for some time previous to total abandonment, several fairly large areas of banana land had been thrown out of cultivation through being unproductive, and a discussion of the conditions obtaining in such unproductive areas is given below.

Unproductive and derelict banana lands.

The most striking evidence of regression of soil type was shown in the nursery site previously described as soil type No. 1.

(*a*) *Regression of soil type No. 1.*

In comparing this soil at the time of abandonment, two to three years after deforesting, with that existing at the time of planting the most marked change observed was the loss of humus covering, and on a larger scale the looseness of the soil mass, evidenced by frequent land-slips, whilst a further feature was the loss of the isolated clumps of forest trees at the tops of the ridges.

The shallow layer of good soil had already been heavily drawn upon and now failed to support healthy banana plants, except in the pockets of good soil which remained at the bottom of some of the slopes. Exposed banks and hummocks were the first to give out and in the subsequent erosion which followed, detritus was carried down on to the good soil and effectually reduced the planting value of the lower areas.

More recent observations show that this degradation has continued until the greater proportion of the surface soil has been transported or covered up and has been succeeded by a soil type of lower agricultural value which supported a secondary flora where practically no bananas were found.

In such sites as remain undisturbed the soil characteristics are markedly different from those observed in the early stages of cultivation, and there is evidence that a definite pan formation has replaced the smooth clay loam formerly in existence. A characteristic soil profile examined in the vicinity of a small banana plant revealed several features. The plant was seen to be susbsisting on the top three inches of humus, which was covered by a compact layer of *Commelyna cayennensis*. The six inches of soil immediately below the layer of humus, was brownish-grey in colour and of a rough, coarse structured loam in which no roots were found. The exposed eight to ten inches of sub-soil below this was a compact grey and uniform silt, free from fragments of loam or humus, and showing a well defined pan formation. The general appearance of the soil, particularly the lower, suggested a thoroughly leached condition, whilst the surface mat of humus preserved from decomposition by the covering of compact vegetation, suggested a podsol or peat formation.

(*b*) *Regression of soil-type No. 2.*

Soil type No. 2 when examined in profile at the present time showed the following characteristics.

I. Much less degradation of soil type as compared with No. 1 viz.: soil—colour and texture and vegetation.

II. That vegetable mould tends to accumulate on the surface, and does not mix with the soil to form humus and cause darkening.

Exposed for a shorter period soil type No. 2 had to a large extent retained its original forest soil characteristics, being protected by windbreaks which had been carefully preserved when clearing this area. The soil appeared as a bright yellow clay with a high water content and no admixture of humus. A large number of bananas were still growing amongst the luxuriant vegetation which had covered this area. The roots of the bananas when examined were found to be water-soaked, with a blackening of the root tip and fine roots. These had in most cases died back after a short period of growth, and showed both fungal and insect attack. It was also noticed that few young banana plants were formed as in the normal course of succession.

A sufficient number of pH determinations were taken by the writer to fix the present reaction of the soil within the range pH 5.9 to 6.3 for the surface three inches, at 5.9 to 6.2 for the six-inch sample, and at 5.9 for the eighteen-inch sample. These reactions were distinctly acid, but not such as to prevent healthy growth.

Present state of banana lands.

(*a*) *Flora.*

Following the abandonment and exposure of the banana lands, an entirely new flora invaded and established itself on the exposed slopes. This consisted largely of weeds common in the distant lower valleys such as might be sown by wind-borne seeds, or arise from seeds expelled by birds, both groups being new to this area. These plants formed small communities existing in the shallow layer of good soil on the exposed sites and as isolated specimens scattered throughout the whole area. Most of them had shallow root development indicating a habitat alternating between drought and waterlogged conditions.

A second important indication of soil conditions was the appearance of associations of *Pteridophytes* including tree ferns, ground ferns and club mosses, with *Heliconia* spp. occupying a wet habitat on the lower slopes and ravine bottoms, where the eroded soil allowed a deeper root range. The Araliad, *Sciadophyllun*, appeared regularly as a solitary specimen on exposed slopes, where a specially adapted root system helped it to withstand the effects of erosion.

(*b*) *Soils.*

The replacement of a fertile soil by an infertile soil is still proceeding on the more exposed slopes and has been greatest in the areas exposed over a longer period (three to five years), so that these soils are at present of little agricultural value. In the areas which have not been totally deprived of vegetation and more recently worked, these changes have been less severe and the soil would respond to careful cultivation.

A detailed survey of these areas would probably reveal many local variations of soil conditions. In some, the exposed soil consisted of powdery volcanic material without quartz fragments resulting from rock decomposition, whereas adjacent areas showed similar denuded rock with fine quartz grit. The examination of road cuttings and many other exposures indicate the general nature of the soil to be as described, but the scarcity of fuller geological information on these soils is to be regretted in view of the importance of the recorded changes to agriculture, and it is recognised that this investigation merely records the main facts of agricultural significance.

Conclusion.

This paper would not be complete without some suggestions for the safe development of forest lands for agricultural purposes.

It has been said that there are two ways of utilising the soil wealth, (1) by systematic cultivation, where the soil is regarded as a reservoir of plant food to be kept in good condition, with a replacement of the material taken off in the crop, (2) by progressive exhaustion, where the soil is regarded as a store house of plant food to be drawn upon without consideration as to methods of replacement, or the conservation of existing materials.

It has been shown that the latter method results in a rapid and progressive depression of the humus content of the soil and a loss of fertility, to a point when the soil is no longer fit for agriculture, and fertility can only be restored by the extremely slow processes of nature.

In tropical agriculture the conservation of humus is of great importance, as external conditions are largely in favour of its rapid destruction. Closely linked with the question of humus is that of soil conditions generally and these as already indicated may be such as to bring about a rapid deterioration of soil type. It is clear that such soils cannot be treated in a haphazard fashion, they must be worked or they will deteriorate rapidly, and one of the conditions of opening up land successfully is that a good standard of cultivation must be maintained.

The following suggestions appear to meet with the principal difficulties in clearing forest land and maintaining agricultural conditions.

(*a*) *Felling and clearing.*

For various reasons this is usually conveniently done in the dry season as the soil is then exposed to desiccation and subsequently to heavy washing during the following rainy season.

This can be largely remedied by the removal of the larger trees only, allowing growth of vegetation to cover and protect the exposed soil and surface humus. This can be followed up by the cutting of bush and final clearing on the approach of the wet season and planting time; areas not required for planting being left for the protective covering of vegetation, which can be subsequently cut for mulch or manure-making.

Where the soil is not protected by a planted crop a green manure crop such as *Crotalaria* or *Tephrosia* could be sown to replace native weeds. Burning bush is unnecessary and wantonly destructive.

(*b*) *Shelter-belts.*

It is highly important to protect forest land by reserving a series of shelter belts of trees of moderate height at the time of felling. The belts should run across and *not down* the slopes, so as to hold up erosive action and modify wash.

Tops of ridges should also be left with a crown of trees of moderate height, as the larger forest trees are unsafe and invariably die when exposed. All belts should be strengthened by planting Galba or *Glyricidia*, both of which can be pruned.

(*c*) *Drainage.*

This should be attended to in the early stages to prevent the formation of many new channels and consequent landslips. Main drains should be carried along the upper and lower edges of the shelter belts at a distance of about 15 feet from the belt, and should outfall into a natural ravine or gulley which should be kept open. Planting could take place on both sides of these main drains so as to economise space. Secondary and crop drains can be decided upon as a full drainage scheme is developed.

(*d*) *Terracing or banking.*

The method of terracing on slopes is an important preventative of wash and facilitates cultivation and transport (a high proportion of the bananas in the Canary Islands is obtained from terraced fields ([6])). Terraces may be conveniently formed in the first instance by half embedding the heavy logs in a direction at right angles to the slope, so that soil and humus accumulate against the upper side of the log and can be consolidated by planting the crop, by green manuring, or by allowing short leaves to cover the surface. The width of each terrace may be determined by the steepness of the slope, a sharp slope requiring more terracing than a gentle slope, and it is not necessary that the terrace itself should be level as a moderate fall will facilitate run-off.

Following these initial operations (if the economic situation will permit) the land may be trenched, sub-soiled and manured, with applications of lime, as indicated by the "working" of the soil and reaction of the crop, and the more ordinary operations of cultivation may be introduced provided the soil is not unduly exposed thereby. Methods of openworking flat lands are not applicable to sloping forest lands, and it is considered that the above suggestions if carefully carried out will go a long way towards preventing soil deterioration and infertility.

The writer wishes to acknowledge the assistance of Dr. C. W. Wardlaw, in commenting on the foregoing notes.

SUMMARY.

1. This paper discusses the effects of deforestation and exposure of tropical forest lands, with particular reference to recent banana lands in St. Lucia observed to deteriorate under commercial exploitation.

2. The conditions of exposure, the effects of erosion, the sequence of soil changes and types of vegetation, are described as evidence of soil degradation, and loss of agricultural value. It is shown that the agricultural development of forest lands is a special case requiring special technique for the preservation and maintenance of the natural high fertility of such areas. Concluding suggestions are made for the improved treatment of forest lands by dividing the exploited area into self protective blocks, with the use of shelter belts and special drains, and the conservation of the soil humus by cover crops, and crop production on terraced slopes.

BIBLIOGRAPHY.

(1) Walters, E. A.—An Account of the Banana Industry in St. Lucia. *Tropical Agriculture*, Vol. V, Nos. 10 and 11.

(2) Russell, Sir J.—The Micro-organisms of the Soil. *Rothamsted Monograph.*

(3) Hill, A. W.—Deforestation in Jamaica. *Journal of the Jamaica Agricultural Society*, Vol. XXIX, No. 12.

(4) Earle, K. W.—The Geology of St. Lucia. *Handbook of St. Lucia*, 1924.

(5) Tansley, A. G. and Chipp, T. F.—Aims and Methods in the Study of Vegetation.

(6) Banana Cultivation in the Canary Islands. *Bulletin of the Imperial Institute*, Vol. 23, 1925.

RAINFALL AND CROP CONDITIONS.

A Review of Rawson's evaluation of the Sugar Crop of Barbados from the Rainfall, 1847-1874.

(*Concluded.*)

By H. M. Leake, M.A., Sc.D., F.L.S.

II

Perhaps the earliest serious effort to trace a relationship between crop and rainfall is that of Rawson, formerly Governor of Barbados, who worked out an evaluation of the sugar crop of that Island from the rainfall using, as a measure of the crop, the figures of the annual export. After a detailed discussion of the monthly and seasonal falls, he reverts to the annual total fall and concludes that, for the period 1857-1872, during which period he considered the conditions of production stabilised, 1 inch of rainfall during the calendar year preceding the crop was responsible for a production of 800 hogsheads of sugar. It may be noted that, in coming to this conclusion, he eliminates the distribution of the rainfall as being of no importance.

A copy of Rawson's report, hitherto known to the writer only by reference, has recently come to hand and the presence in it of the daily rainfall figures for the years 1847 to 1873, together with the general reliability of the figures presented, not only provided the data necessary for carrying out an analysis but appeared to justify the considerable arithmetical labour involved.

Table II summarises the results obtained; column 2 giving the actual production of sugar (amount of sugar in thousands of hogsheads exported during the year of harvest), column 4 the yield as calculated from the regression equation based on the coefficients of correlation noted above with the years 1857-1873 inclusive used as basis, and column 6 the percentage divergencies of the calculated from the actual.

The application of an equation derived from yield measured in tons of cane per acre to production measures in hogsheads of sugar exported constitutes a not inconsiderable extension of the method and one which, it might be anticipated, would introduce disturbing influences of a magnitude sufficient to mask any dependence that might actually exist. It is desirable, therefore, to consider the nature of those influences and the information concerning them.

(1) *The application of the formula to an extended area.*

As was indicated in the original paper, the particular value to be given to k is dependent on the nature of the soil and the use of the effective rainfall is, therefore, limited to areas having a relatively limited range of soil types. In the present instance this condition is fulfilled, Barbados being essentially a coral formation.

(2) *The acreage grown.*

On this particular there is no information. The Island is, however, one of the oldest of British settlements and has been intensely cultivated for a long time past. It is probable that the area cultivated has been stabilised within narrow limits since the effects of the Emancipation of 1834 passed. Rawson evidently assumed a stable acreage for he makes no direct reference to the point, his only remark bearing on the subject being :—

During the years immediately preceding and following Emancipation the crops were more or less affected by the irregularity of labour. The year 1847 was the first in which the crop recovered from the effects of that measure and again :—

For some years past the greater portion of the Island has been under cultivation. A nearly uniform system has been adopted.

(3) *The reliability of the rainfall data.*

The data on which this analysis is based are not above criticism on this ground. The figures used for the calculation of the effective rainfall are based, for :—

1847-1851 on the returns of one gauge.
1852-1853 on the returns of two gauges.
1853-1872 on the returns of three gauges.

These are undoubtedly inadequate for a really reliable estimate of the rainfall of an area of some 166 sq. miles but the inadequacy is minimised by the conformation of the Island. In Rawson's words :—

There is little in the surface of the Island to attract or promote rain.

(4) *The Application of the method to a manufactured product.*

This introduces a potential source of error, for the assumption is made that a given weight of cane produces a given weight of sugar, an assumption that would not be justified at the present time but is probably sufficiently correct where the product is Muscovado sugar. The point which it is important to ascertain is whether any material alteration has taken place in the method of manufacture during the period. On this point Rawson remarks :—

The progress (? process) of manufacturing sugar is nearly the same. Improved systems have been introduced to a limited extent and increased attention to existing processes is of recent growth.

(5) *The use of the export figure as a measure of production.*

On this point Rawson speaks with more assurance than on any of the former. He writes :—

Almost the whole of the sugar manufactured —probably within two per cent. of a good crop, or five per cent. of a bad one—is exported. It is generally shipped within the year in which it is manufactured. If otherwise, the customs have the means of distinguishing the small remnant, and of including it in the crop to which it belongs.

TABLE II.

YEAR.	Rainfall previous year. (inches).	Actual production (1,000 hhds.)	Calculated from the effective rainfall.				Calculated by Rawson's method.		
			Per cent. crop yield.	Production (1,000 hhds.)	Difference actual and calculated.	Per cent. difference on actual.	Production (1,000 hhds.)	Difference actual and calculated.	Per cent. difference on actual.
	1	2	3	4	5	6	7	8	9
1849	63.77	33.08	126	50.32	+17.24	+ 52.1			
1850	52.77	35.30	115	45.93	+10.63	+ 30.1			
1851	67.88	38.73	142	56.97	+18.24	+ 47.3			
1852	59.40	46.61	119	47.75	+ 1.14	+ 2.4			
1853	58.77	38.72	114	45.73	+ 7.01	+ 18.1			
1854	68.84	45.18	138	55.37	+10.19	+ 22.5			
1855	50.88	39.29	105	42.13	+ 2.84	+ 7.2			
1856	77.31	43.08	137	54.97	+11.89	+27.06			
1857	48.49	38.80	104	41.73	+ 2.93	+ 7.5	40.03	+ 1.32	+ 3.2
1858	60.90	50.79	114	45.73	− 5.05	− 9.9	51.31	+ 0.52	+ 1.0
1859	45.22	39.67	94	37.72	− 1.95	− 4.9	37.68	− 1.99	− 5.0
1860	54.22	42.69	115	45.93	+ 3.25	+ 7.6	40.78	− 1.91	− 4.4
1861	57.91	49.74	121	48.55	− 1.19	− 2.4	48.03	− 1.71	− 3.4
1862	73.82	46.12	139	55.77	+ 9.65	+ 20.9	63.27	+17.15	+ 36.9
1863	59.27	42.28	120	48.15	+ 5.87	+ 13.9	48.45	+ 6.17	+ 14.6
1864	42.38	36.12	90	36.11	− 0.01	± 0.0	37.59	+ 1.47	+ 4.1
1865	59.19	46.07	123	49.35	+ 3.28	+ 7.1	49.67	+ 3.60	+ 7.8
1866	68.64	57.19	135	54.17	− 3.02	− 5.3	58.86	+ 1.67	+ 2.9
1867	59.68	51.30	112	44.94	− 6.36	− 12.0	46.79	− 4.51	− 9.6
1868	69.93	58.25	143	57.38	− 0.87	− 1.5	58.95	+ 0.70	+ 1.2
1869	44.60	32.15	94	37.72	+ 5.57	+ 17.3	39.41	+ 7.26	+ 22.6
1870	48.52	39.27	105	42.13	+ 2.86	+ 7.2	44.19	+ 4.92	+ 12.5
1871	60.17	53.91	134	53.77	− 0.14	− 0.3	53.52	− 0.39	− 0.7
1872	41.46	39.16	92	36.91	− 2.25	− 5.7	36.42	− 2.74	− 7.0
1873	48.36	47.23	84	33.70	−13.53	− 28.6	36.38	−10.85	− 22.9
1874	59.22	65.00					47.38	−17.62	− 27.1

These considerations, while necessarily detracting in some measure from the reliability of the results, give no grounds for supposing that errors occur which are greater than those inherent in data of this nature or that any broad interpretation based on results derived from their use will not be justified. Those results, given in Table II, require little comment. They show that, of the 16 years, 1857-1872, during which, in Rawson's estimate, conditions were stabilised :— in *five* cases agreement between calculated and actual is less than five per cent.; in *seven* cases agreement between calculated and actual is greater than five per cent. and less than 10 per cent.; in *two* cases agreement between calculated and actual is greater than 10 per cent. and less than 15 per cent.; in *one* case agreement between calculated and actual is greater than 15 per cent. and less than 20 per cent.; in *one* case agreement between calculated and actual is greater than 20 per cent.

Table III gives certain additional information. The mean percentage difference of calculated on actual is +0.32 hogsheads, the positive sign having significance. In standardised processes such as cane sugar production, of which the object is to obtain the maximum production, any fault in the process is more likely to produce a diminution of outturn than an increase. Divergencies will not, therefore, be equally distributed and the excess of calculated over actual is in accord with expectation and strengthens belief in the actuality of the calculated figures. It is noteworthy, too, that in the years 1862, 1863, 1867 and 1869, in which the difference between actual and calculated is most marked, there is a considerable difference between the total rainfall as recorded by Rawson for the Island, being the average of all stations numbering variously from 20 to over 40, and that of the three stations only of which daily rainfall data are available, and that these differences are in all cases in the direction of approximating the calculated to the actual.

Beyond this it does not appear advisable to press the interpretation of the results. Broadly speaking, they support the conclusions arrived at in previous work as to the value of the effective rainfall as a measure of the agricultural value of rain, while they illustrate one of the directions in which an economic use of that conclusion may be found.

In columns 3-6 of Table II the calculations are carried back to the year 1849 which involves the rainfall of the year 1847. These figures show a 'seasonal trend' of considerable magnitude. During the period, accepting the conclusion drawn from later years, conditions were clearly not stabilised. At this distance of time, and with only a passing acquaintance with Barbados, it is difficult to trace the cause of that trend. Rawson, writing with the greater assurance given by the smaller lapse of time and the knowledge at the disposal of the Governor, points out that it synchronises with the introduction into general use of manures and especially guano, which began to be imported into the Island in considerable quantities about that time. In the other direction the figures calculated by Rawson's method have been extended to the year 1874 because the returns of the last year give by that method, as he points out, an abnormally high actual. The actual yield for the year 1874 exceeds the calculated by an even larger amount and it raises the suspicion that a trend of a still higher level is becoming effective. If this be so, the abruptness of the change suggests some economic cause for, in its abruptness, it is comparable to the change noted about 1856.

In columns 7-9 of Table II and in Table III are given the corresponding calculations based on Rawson's method. From the latter table it

TABLE III.

	Effective rainfall method.	*Rawson's method.*
Mean of per cent. differences on actual	+0.32	+0.48
Standard deviation of per cent. differences on actual	9.59	12.51
Coefficient of correlation, calculated and actual ..	+0.85	+0.78

appears that, here also, the percentage difference between calculated and actual production is positive, being +0.48 hogshead. The standard deviation of the percentage differences is, however, greater in the case of Rawson's method while the coefficient of correlation between actual and calculated is smaller, results which indicate that the effective rainfall method is somewhat more reliable.

Rawson, however, proceeds further and makes an attempt at closer approximation. He states the full formula for calculating the outturn of any year to be :—

Multiplying the total rainfall of the preceding year by 800 and adding 7½ per cent. if the year was a dry one, or deducting 7½ per cent. if it was a wet one.

The results he obtains by this extension of his original formula certainly constitute a closer approximation to the actual but it would seem very doubtful whether there is any underlying reality. If the extremes of rainfall failed to produce the average effect as here suggested, it would be anticipated that the failure would be proportional to the degree of divergence and not a constant figure; whilst, in years of moderate rainfall, no allowance would be required. Not only is the allowance made by Rawson in every case but, as the following figures indicate, at intermediate values the 7½ per cent. is added or subtracted indiscriminately :—

Year.	*Rain.*	*Actual yield.*	*Yield calculated at* 800 *hhds.*	800±7½%*hhds.*
1862	59.27	42,281	47,416	43,861 subtracted.
1866	59.68	51,304	47,744	51,323 added.

The correction does not appear to be supported by facts.

The results here given in the case of sugar production in Barbados confirm the view formerly expressed, that the effective rainfall constitutes a valuable means of interpreting numerous phenomena of agricultural production in the tropics. That a greater degree of accord between calculated and actual is not forthcoming in the present instance, and that a marked divergence is found in a few instances, is not surprising in view of the material and of the lapse of time. Who, for instance working 50 years hence with data of certain districts of India, will trace certain abnormalities in the statistics of 1919 to the influenza epidemic of 1918? Yet that epidemic, coming as it did at the cold weather sowing season, was responsible for large reductions in the areas sown. Full accord, where no record of such extraneous influences exists, is not to be expected. Such an analysis as that given does, however, emphasise the desirability of further work both on the method of determining the effective rainfall—for, at best, the effective rainfall value, as here used, can only be considered a first approximation and the scientific bases for that evaluation require much elucidation—and its economic application. On the latter score there can be little doubt that there is an immediate field for the application of the effective rainfall, even in its present form, to the solution of present day economic problems of tropical agriculture.

Finally, attention may be drawn to the general similarity of the results obtained by the two methods described above. It may be thought that the advantage of the more tedious method by means of the effective rainfall is insignificant. This, no doubt, is true. The possibility of applying so simple a method as that of Rawson is due, however, to the exceptional uniformity, both in distribution and amount, of the rainfall of Barbados. During the period under review the range of the total annual fall extends from 41.5 in. to 77.3 in., giving a maximum approximately 180 per cent. of the minimum. In the series analysed in the earlier paper (1) and dealing with the cotton crop of the Dhulia farm, the range extended from 7.9 in. to 36.7 in., a maximum over 460 per cent. of the minimum. The following figures give an idea of the relative distribution of the rainfall of Barbados and Dhulia and show the relative uniformity of the distribution in the former case. Both refer to the 16-year periods analysed.

	Average annual fall.	*No. of falls between* 2 & 3 *ins.*	3 & 4 *ins.*	4 & 5 *ins.*	5 & 6 *ins.*
Barbados	55.5	24	4	3	—
Dhulia	19.3	7	2	2	2

In the latter case the correlation co-efficient, as usually determined, is meaningless since the relationship between the total fall and the cotton crop is not linear, while that obtained with the use of the effective rainfall is significant, for the relationship is approximately linear, and has a value of +0.70. It is possible, therefore, to apply the method based on the effective rainfall to cases to which the simpler method is inapplicable. Such an application has, in fact, been made to so complex a case as cotton with its divergent moisture requirements at different stages of its growth and growing under such varied distributions of rainfall as occur at Dhulia.

(1) Leake, H. Martin—The Agricultural Value of Rainfall in the Tropics. *Proc. Royal Soc.* B. (28), 103, p. 82.

YELLOW FEVER IN AFRICA.

DR. AUGUSTE PETTIT, Professor at the Institut Pasteur de Paris, who with Dr. Stephanopoulos was sent to Senegal, French West Africa, last winter to study the epidemic of yellow fever, has recently communicated his observations to the Academy of Medicine. The first part of his report, as summarized in the Journal of the American Medical Association, is devoted to the memory of the eminent scientists who succumbed there to the disease: Stokes, Young and Noguchi. The death of Noguchi is all the more regrettable because of the fact that the researches that he undertook have been abandoned, while all the monkeys inoculated by him have been allowed to die. They were valued at half a million francs. Furthermore, the government of French West Africa has issued an order prohibiting the inoculation of the monkeys of the colony for fear that they may become adapted to the virus, and that, on escaping, which is a frequent event, they may serve to spread the infection. Dr. Pettit made use of a species of monkey of the genus *Macacus*, brought from India, and carried on his researches at the Institut Pasteur, using a virus from Senegal that was furnished him by Professor Sellards, of Harvard University. His first conclusion is that the agent of yellow fever is not a spirochete, as Noguchi believed, but an invisible filtrable virus. That was the opinion advanced also by the Marchoux mission in 1903. This virus can be inoculated into monkeys, and the sick monkeys are cured by injecting into them the serum of a human being who has recovered from yellow fever. Dr. Pettit succeeded in preparing an attenuated virus that serves as an effective vaccine for the protection of monkeys. He has prepared 600 vials of this serum, which is a genuine protective and curative agent. It remains to be discovered whether the serum of these vaccinated monkeys will serve, in turn as a vaccine for man. That is the problem with which Dr. Pettit is engaged at present, and in view of the results already secured, he feels that it is probable. His researches have been hindered through lack of monkeys, owing to an advance in price since thay have been used in Europe for testicular grafts, and the funds at the disposal of the mission are now inadequate. (*Science*, Vol. LXVIII, No. 1774.)

NURSERY WORK.

The Plant Nursery in the Tropics.

(*Concluded.*)

BY R. O. WILLIAMS,
Superintendent, Royal Botanic Gardens, Trinidad.

Propagation Methods.

Avocado.—Since the year 1916 the vegetative propagation of the avocado has formed part of the routine work of the St. Clair nursery. Before that date the work was only experimental and more or less successful.

Stocks.—Large seeds are sown direct in bamboo pots. Those making vigorous growth are selected and budded when about six or eight weeks old and still reddish brown in colour. It is essential to bud whilst the stocks are very young as the bark soon hardens with age and owing to its liability to split is the cause of many failures.

Scions.—These should be taken from the young branches; the best buds are those which occur from near the top to about 12 inches down the stem, where the bark is usually of a green colour. If the leaves have not fallen naturally they should be cut off at the base of the leaf blade a week or so before the buds are required. The buds should be dormant, plump and fairly well advanced, taken off with about ½ to ¾ of an inch of bark and inserted in the stock by the well known T method. They make a quick union and growth is remarkably rapid.

Once the bud has united with the latter it should be trimmed four or five inches above the point of union, but not until the bud has made several inches of good strong growth and a complete union. If stocks are cut back closely before the buds have properly united they often die back below the incision of the bud.

Another important factor is the season in which to bud. Avocados ripening in August, September and October give stocks for budding before the rainy season ends. Unless a glass covered shelter is available in which to place the plants before a union is made, budding must be deferred until the early months of the dry season, selecting seeds from late fruits for use as stocks, to allow them being of the right age. The experience at St. Clair has been that many young plants are lost, even after budding under shelter, if exposed to heavy rains.

Splice grafting the Avocados.—Avocados may also be propagated by splice grafting. The stock which should be about six months old is prepared by taking the head off with an oblique cut 2 to 2½ inches long. The scion is a young growing shoot about three to four inches long, the stem being still green. All its leaves are removed and it is cut similarly to the stock, the two being fitted together and bound with prepared tape. In two or three weeks a union is effected and the scion soon after bursts into growth.

Wedge grafting can also be successfully used for avocados, the stock being cut flush at about one foot from the ground. A vertical slit is then made through the middle of the cut and the scion which is trimmed in the form of a wedge, is inserted and bound.

Avocado trees respond readily to top-working and either of the above methods may be used, or patch budding as with cacao is applicable. Where it is intended to top-work by the T method it will be necessary to prepare the stock tree by cutting it back hard and then budding on the young shoots produced.

Citrus.—The Citrus industry of the past has been principally confined in the B.W.I. to limes in Dominica and Montserrat, and to oranges and grapefruit in Jamaica, practically all of which have been propagated by seeds. The grapefruit industry promises now to assume commercial importance in some of the islands (*see* table, Vol. VI, No. 2, p. 36). If this is to be successful it will be essential to plant only vegetatively propagated plants from good mother trees. The trees readily respond to the T method of budding which has been used with a high percentage of successes on a small scale for many years.

As it is a new industry the methods for selection work for stocks and scions have largely to be copied from other countries where climatic conditions are somewhat different, but the same general principles will undoubtedly apply with perhaps minor modifications as the industry extends.

Stocks.—The sour orange, or goospore as it is called in Grenada, has so far proved the best stock for most places in these islands, and for most varieties of citrus fruits. A notable exception, however, is the Satsuma orange which is dwarfed on sour orange stock, whilst on Tangerine it makes very rapid growth. The Navel Orange also makes much slower growth on sour orange than do other varieties. The seeds should be taken from the fruit, washed and sown thinly in well drained beds made of light soil and exposed to full sunshine. A light spraying should be given weekly with Bordeaux mixture to prevent casualties from the "damping-off fungus" and to avoid check to growth from scab disease, to which they are highly susceptible.

When about six inches high the seedling should be transplanted to well tilled and manured beds at a distance of 15 inches apart. It is advised ([10]) that selection at this stage should be made for crooked or bench roots. In Trinidad selection for this character worked out in 1928 to 86 per cent. rejections. Weakly seedlings at this stage should also be discarded.

It is not advisable to grow the seedling stock in bamboo pots as the root system gets cramped and the growth of the plants is not sufficiently vigorous to make a success of the actual budding operation. Nor is it advisable to sow the sour orange seed at stake in their permanent places in the orchard. The person who cannot afford to pay for nursery plants obviously cannot afford to pay for the additional supervision which they will require under such conditions in the field.

The budwood from which the buds are to be taken should be from trees of known good characters of the required variety of grapefruit, oranges, &c. as the case may be. These mother trees need watching for chimeras or sports such as branches producing thick-skinned mis-shapen fruits or other bad characters, such as seeds for instance, in a so-called seedless fruit. These branches must be removed as soon as observed to avoid the possibility of using them as budwood. This of course is no actual guarantee that some of the buds used may not prove to be "undeclared" chimeras but it is the best that can be done under the circumstances.

The budwood should be green barked wood near the end of the branches, round in shape and about the thickness of a lead pencil. The young angular tops are too young to be suitable for budwood.

Stocks well grown should be fit for budding at six to nine months, *i.e.*: when they are about the thickness of a lead pencil. A ⊥-shaped incision is made in the stock at about 10 inches from the ground under the bark, and a bud with about half an inch of bark, both above and below, is gently inserted upwards. The whole is then bound firmly with prepared tape, and the bud left exposed. In about 10 to 14 days a callus should have formed and the tape may be removed, except that it is generally the practice to leave about two wraps around the transverse cut for another week or so to prevent it opening. If the bud is still green it is likely to grow, and in this case the top of the stock is usually cut half through and bent over. When the bud has made about half an inch of growth the stock should be cut back "flush" to the top of the bud and the cut treated with crude oil. It is a common practice to leave a snag which is either cut back later or left. This method is to be condemned as the earlier the stock is cut back "flush" the better union will stock and scion make. The same remarks apply to early budding. The stocks should be worked as soon as ready. Sometimes the stocks are allowed to get quite woody before budding, but this is not advisable as it may take two or three years before a smooth union is made.

The young budded tree should be trained to a straight stake to a height of about 30 inches and headed back to a height of two feet from the ground. Several primary branches should then be allowed to grow to form the main frame work of the tree. Under tropical conditions the tree will be ready for transplanting from the nursery to its permanent situation about six or eight months after budding.

Limes.—The West Indian lime comes true to type from seed and up to recent years there has been no real necessity for vegetative propagation. With the advent, however, of wither-tip disease this has now become necessary. Efforts are being made to produce by cross breeding a lime which, while answering the varied requirements of the trade will not be susceptible to the drastic action of wither-tip disease. If such is obtained the selected variety will have to be propagated vegetatively as in the case of grapefruit and oranges. An additional reason for budding on to another stock is the deadly effects of red root disease.

Raising limes from Seed.—Owing to the susceptibility of lime seedlings to "damp off" soon after germination, and to wither-tip disease, seeds must be sown without shade in sunny, exposed, well drained beds, as free as possible from decaying vegetable matter and manure. Seedlings are raised best during the dry season and seeds should be sown about January or February, in drills about one inch deep, or broadcasted. When about three inches high the seedlings can be transplanted to other beds or bamboo pots, although it is not necessary to use the latter as they can be successfully moved and transplanted "bareroot." The seed beds should be sprayed lightly every week with Bordeaux mixture for disease prevention.

Mangos.—The best varieties of mangos may be propagated by budding or grafting; inarching or grafting by approach is the usual method and is conducted in the same way as for cacao. The stocks are the common hardy mangos, germinated in beds and later transplanted to bamboo pots. They are ready for grafting at about nine months old. By the inarching method an expert propagator may expect 100 per cent. successes and his trees are ready for planting in the field about two weeks after being taken from the parent trees. Budding and grafting in receptacles by other methods have not proved practical at St. Clair, and propagation by grafting by approach is undoubtedly the cheaper and more certain method.

Patch budding done in a similar way as suggested for cacao is a useful method for working over older common trees ([11]). The trees should be cut back to within a foot or so of the forking of the main and primary branches when it will produce young shoots which must be thinned, and then treated for budding in a similar manner as a cacao stock in a bamboo pot.

Transport.

Most of the plants grown in the St. Clair Nursery are despatched by lorry or open trucks to plantations in bamboo pots, packed into rough crates ten inches deep, by two feet six inches long, by one foot ten inches wide, which hold about fifty plants.

With citrus grown in beds until they are ready for planting out, no receptacles are needed if planting is to be done immediately. For convenience of transport, however, plants are generally placed in bamboo pots. A tool with two semi-circular blades is pressed down around the plant to be lifted; this cuts out a circular piece of soil with the roots, about eight inches long by four and a half to five inches in diameter. A bamboo joint of similar dimensions is split in half and put around the soil and firmly tied. A little soil may be added to fill up odd crevices, and if the plant is soaked with water it will suffer little check from the transfer. Plant out in the orchard as soon as possible by cutting the tie and removing the pieces of bamboo. With this method of transplanting, beheading of the young plants is not necessary.

Plants which are to be despatched "bareroot," should be dug early in the morning before the sun is hot, or on a wet day. Care must be taken not to injure the root system, and any roots which may be accidentally damaged must be cut off. The tree must be beheaded by shortening the primary branches. The roots are puddled in thin mud and wrapped immediately in bundles in moss or coconut fibre or wet sacking. Limes and coffee can be packed similarly, although this method may give the latter a rather severe set back.

For transport by sea, plants require packing in deeper crates with their upper parts protected. Each row of pots must be firmly held in position by a wooden cleat, nailed immediately across the top of each row. This is a simple detail, but many a shipment of plants is ruined through neglect to fasten the pots in position.

Long distance carriage of tropical plants by sea has to be specially provided for. This is done by means of a Wardian case, really a miniature green house, a ventilated box with a glass span roof, protected by wooden laths. The plants are packed tightly amongst coconut fibre or some other moisture holding material and cleated in position and will travel thousands of miles, without attention, in perfect condition. In this way many important tropical plants have been transported from one part of the world to another.

REFERENCES.

(10) Powell, H. C.—Review of Grape Fruit production, British Honduras.—p. 5 (1928).

(11) Williams, R. O.—Fruit Cultivation, Trinidad and Tobago.—pp. 73-84.

ACKNOWLEDGMENT.

We have to acknowledge, with thanks, the gift of three valuable old books—one botanical and two entomological—presented by Claude Connell, Esq., and also a copy of "Explanation of Terms Used in Entomology" by J. B. Smith, presented by Mrs. J. R. Bovell.

A PARASITE "ZOO."

Work of Empire Laboratory.

The laboratory for breeding beneficial parasites, established by the Empire Marketing Board and under the control of the Imperial Bureau of Entomology, has now been actively at work for rather more than a year. Consignments of insects have already been sent out in response to requests from Canada, New Zealand, Australia, South Africa, Kenya, the Falkland Islands, and different parts of England. Between 20,000 and 30,000 larvae of the Pine Tortrix, 90 per cent. infected with a parasite which attacks it in its larval stage, were recently collected (largely from Brandon, in Suffolk) for Ontario. Ontario also received 20,000 parasites of the greenhouse white fly, which was exported on whole tomato sprigs and sent over in cold storage. Adult parasites of a scale insect which attacks fruit were sent over in small sealed test-tubes to Vancouver and provided with raisins for nourishment in transit.

The sheep blow-fly, a big greenbottle, lays its eggs in dirty and matted wool on living sheep, and the maggots which hatch out eat their way into the animal's body. There is, however, a parasite which in turn lays its eggs in the blow-fly maggot, and eventually kills it. Hundreds of thousands of these maggots, with their appropriate parasites are being bred at the laboratories, and some have already been exported in the chrysalis stage to Australia, South Africa, and the Falkland Islands, where the blow-fly causes enormous loss of sheep life. Other recent exports include parasites of the woolly aphis of the apple, sent to India and Kenya Colony, and of the earwig, sent to New Zealand and Canada.

Three Australian scientists from the Commonwealth Department of Entomology are at present carrying out research at the laboratories under the Superintendent, Dr. Thompson, who is himself a Canadian. One is working on the sheep maggot, or blow-fly, mentioned above; one on a parasite of the apple-ravaging Codling Moth, and one on an insect which attacks a troublesome weed, St. John's Wort. Dr. Myers, of the Farnham Royal Staff, has gone to the West Indies to deal with tropical parasites, and he will organise shipments of beneficial insects between the various islands and British Guiana. At the same time the possibilities are being explored of conveying a parasite of the Pink Poll Worm from the Sudan to Barbados, with Farnham Royal as a transmitting centre.

(*Extracts from a letter by Major Walter Elliot, Chairman of the Research Grants Committee Empire Marketing Board, which appeared in the "Weekly Times" of 29th November*).

THE CHEMISTS' EXHIBITION.

Members of the drug trade are invited by the Organisers to visit the 35th Chemists' Exhibition which will be housed from 27th to 31st May, in the New Hall of the Royal Horticultural Society, Westminster. Admission on presentation of trade card.

VITAMINS.

By Alfred Clark, F.R.C.S.
Acting Govt. Pathologist, Trinidad.

I—Introductory.

Until the second decade of this century the value of foods was considered almost entirely in terms of calories and certain arbitrary proportions of proteins, carbohydrates and fats.

So long as the fuel requirements and the tissue repair requirements, as estimated by the daily production of carbon dioxide and urea, were provided for, the diet was thought to be a satisfactory one. Here and there, it is true observers had noted an apparently inexplicable association between certain conditions of ill-health and dietaries which were abundant enough in quantity but lacking in variety.

For instance Livingstone in 1857 recorded his observation that a peculiar eye-affection occurred amongst his followers at a time when their diet was restricted to coffee, manioc roots and rice. Nowadays we recognise this condition as a result of a lack of vitamin A in the diet. Again in 1899 Eijkman, working in Java, noticed that Beriberi, a disease of rice-eating countries, was associated with the consumption of polished rice as the main article of diet, whilst the inmates of prisons where the daily ration consisted of unpolished rice were exempt from the disease. He noted also that the polishings of the grain were an effective remedy.

All vitamins are produced by the action of vegetable cells, probably as a bye-product of their functional activity; not for their own benefit and certainly not for ours.

Although many attempts have been made to obtain them in a pure form and products in which they are contained in high concentration (1) and, in the case of vitamin B, even crystals which are of great efficiency have been prepared, it does not appear that any one of them has been actually isolated and, with the possible exception of vitamin D, our knowledge of their constitution is still very uncertain.

One fact however seems to be firmly established and that is that they exist in plant cells only in such infinitesimal quantities as are comparable to that of radium in pitch blende.

It has been recently suggested that they may not be chemical bodies at all but rather that their attributes are akin to the radio activity of atoms and may be identical with that manifestation of energy.

Another theory compared them to the internal secretions of the endocrine glands and thinking them of a similar nature the name of "vegetable hormones" was suggested.

(1) The administration of 0.0001 milligrams of irradiated ergosterol is sufficient to cure rickets in a rat and a daily dose of two milligrams will prevent rickets in a child up to the age of one year.

Still another theory placed them in the class of the catalysing substances.

Casimir Funk thought they belonged to the amines and it was he who suggested the title of "vitamines." It has since been proved that, whatever they may be, they are not amines, but the name has been retained as a convenient term and is now universally used, but the final E has been cut off to avoid the confusion that might arise from the use of a word implying a knowledge which we do not possess of the structure of these elusive but indispensable factors of our daily food. Vitaminologists seem to have a most laudable desire to insist upon the blanks in their knowledge.

Small as is the quantity of vitamins required for health it is certain that the absence of vitamins A, B or C, from a diet is incompatible with life, and that an insufficient supply of any of the vitamins is incompatible with health.

To the statement that all vitamins are produced by the activity of vegetable cells it is sometimes objected that carnivorous animals thrive upon a purely flesh diet. The answer to this objection is that the carnivora devour the herbivora and obtain their supply of vitamins from the tissues, especially the internal organs, of their prey. As an illustration it may be pointed out that the food in the case of the cod fish consists of smaller fish, such as sprats, that the sprats live on smaller fish (the copepods) and that the copepods live upon diatoms which, of course, belong to the vegetable kingdom. It reminds one of the house that Jack built.

Closely associated with the subject of vitamins and needing careful discrimination in all experimental work in dietetics are :—

(*a*) The amino-acid constitution of the proteins supplied during the experiments.

(*b*) The mineral salts contained in the diet.

The molecules of the different proteins differ widely in their amino-acid constitution and some of these amino-acids are necessary to life, others to growth. Zein for instance, which is the protein constituent of maize, contains neither tryptophane nor lysine and therefore cannot support life nor permit of growth.

With regard to the mineral salts in the diet our knowledge of their place and relationship to vital metabolism is very incomplete but certain facts have been observed which indicate that they fulfil important functions which are connected with the activities of the vitamins.

The increased requirement of vitamins A, B and D for animals fed upon a diet in which the quantity of magnesium is high is an instance which points to the great importance of this vitamin-mineral relationship.

To illustrate the results of feeding on a diet deficient in all the vitamins as compared with those obtained by giving a properly balanced diet I append a graph showing the growth of a

litter of six young albino rats. Four of these were given the following vitamin-deficient diet in an unrestricted quantity :—

Diet No. 1.

Polished rice	25 per cent.
White flour	35 do.
Sugar	25 do.
Salt fish	15 do.
Lard compound	10 do.

For drink they were supplied with an infusion of Indian tea, *ad libitum*, and they soon developed a distinct liking for the beverage.

This diet is similar to that consumed by many East Indian families.

The two remaining members of the litter were given in unrestricted quantity a diet composed as follows :—

Diet No. 2.

Whole wheat flour	47 per cent.
Barley meal	35 do.
Cheese	8 do.
Fresh meat	2 do.
Cod liver oil	5 do.
Marmite	3 do.

This contains all the vitamins and other required food substances in adequate quantity.

These two rats were given water to drink. The results are exhibited in the graph and are obvious enough.

The animals on Diet 1 did not grow at all. On the thirty-first day two of the four were put with the two control animals and shared their diet (No. 2). Growth was at once resumed. Of the two remaining on Diet 1, one died on the thirty-third day and the other was given Diet 2. He then recommenced to grow.

A post mortem examination of the one which died showed small haemorrhages in the kidneys, ulcerative lesions of the mucous membrane of the intestine and marked thinning of the muscular coats of the intestines.

It may not be out of place in such an article as this to call attention to the economic question of whether the rate of wages of the working classes is high enough to enable them to purchase the vitamin containing foods which are needed for their health and industrial efficiency.

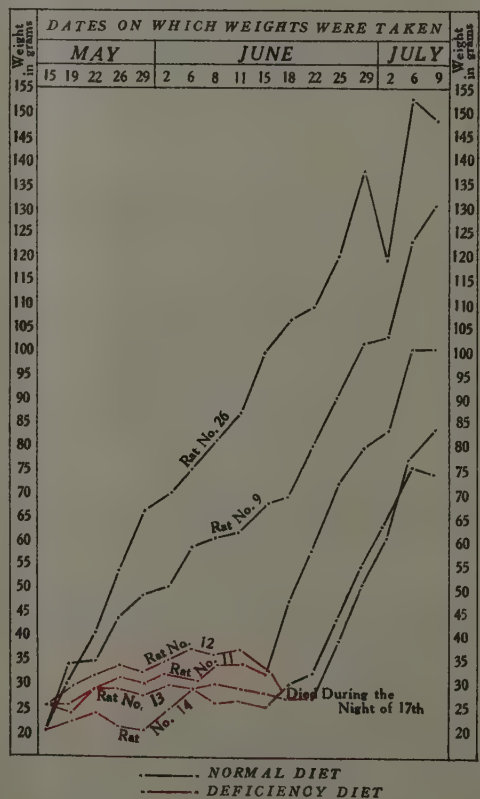
In considering this matter we shall do well to remember that with a queer and rather inexplicable perversity the common foods of civilised people in all countries, but especially in the tropics, appear to be selected, refined and cooked on such lines and by such methods as ensure the rejection or destruction of vitamins. Amongst the wealthier classes the loss is to a certain extent, but by no means completely made good by the consumption of milk, cheese, eggs and other luxuries which are comparatively expensive articles. These articles are, however, beyond the reach of a large number of the population.

The question also arises of the extent to which State interference in the food supplies of the people is advisable.

The provision of sufficient water of good quality, of pure air, of satisfactory sewerage, and the proper lighting of all buildings are at present matters of legislative concern. It seems inevitable that the equally important matter of the control of food supplies will be extended from the mere inspection and condemnation of actually poisonous commodities to the insistence on a satisfactory nutritional value in the common articles of diet. There are many other economic considerations involved in connection with the food supply of every country which would be beyond the scope of this article as well as beyond the range of the writer's acquaintance with "the gloomy science." Somewhere no doubt the statesman who will face and deal with these problems is growing up. Perhaps he is already at the University; perhaps still in the nursery. I hope he is at least born.

CHART

SHEWING EFFECTS OF DIETS ON RATS



(To be continued.)

AGRICULTURE IN CEYLON.

By R. Cecil Wood, M.A., Dip. Agric.

The report of the Ceylon Department of Agriculture, for the Calendar Year, 1927, is of particular interest, in view of Mr. Stockdale's appointment as Assistant Agricultural Adviser to the Secretary of State for the Colonies, for it is probably the last he will write about the Ceylon Department. Mr. Stockdale assumed charge as Director in December, 1916, and in the last eleven years has seen the Department expand very greatly: its present well established position is due largely to his careful control and sound judgment.

So far as it is possible to generalise about a report that covers such a wide field, the activities of the Ceylon Agricultural Department are largely concerned with the prevention of the very heavy losses which are caused to the soil by erosion, and the building up of a reserve of fertility in the soils thus stabilised. That, on the slopes which characterise much of the cultivated area of the island, erosion can be a very serious loss, is shown by actual measurements made on two experimental plots, which recorded a loss respectively of six and ten tons of soil an acre in the course of a year. Both the above objects are attained by growing cover crops, which will be thick enough to prevent wash, and at the same time will provide enough material by the incorporation of a whole or part of their growth in the soil to increase the soil fertility, and the Department has under observation and trial a large number of crops which possess merit in one or other of these directions. The most generally suitable is *Indigofera endecaphylla*, and a gratifying increase in the demand for its seed—as well as that of other crops—is recorded. Another favourite is *Dolichos Hosei*, unfortunately referred to as Vigna, a name which is likely to cause confusion. The use of such cover crops is recommended even for coconut plantations in the coastal, and therefore less undulating areas, and in this direction it is possible that the reversion from "clean weeding" has been somewhat overdone. Sampson practised inter-cultivation successfully in coconut stations in Malabar, a method which is still maintained ([1]) and is still claimed to give the best results. It is, of course, largely a question of the moisture in the soil, all of which may be needed for the major crop; preliminary work which has been done in Ceylon, indicates that although such crops at first decrease the moisture in the soil, later, when they have become established, they cause an increase.

The question of the decomposition of such green manures when dug or ploughed into the soil is under investigation, and it is claimed as a result of preliminary experiments that the nitrogen in such a case is completely nitrified in the course of six months. Further work to determine this actually in the field, where the green crops have been grown, has been initiated and is in progress. The whole problem is of the greatest interest to Tropical Agriculture, and the Ceylon Department is to be congratulated on its comprehensive programme of attack.

Much detailed work has also been done on various crops, particular attention being paid to rubber, coffee and rice. Mr. Stockdale has recently outlined the progress that has been made in the budding of rubber([2]), and the position to-day is that the industry in Ceylon looks to greater commercial success from seed selection than from the establishment of large areas of budded plants. Budding is being utilised to reproduce rapidly stock of high value from which selected seed can be obtained. The work on rice progresses steadily, and a considerable amount of information has been obtained on the value of some of the pure line strains, which have been evolved by the Botanist and his assistants. A paper on the field plot technique of rice plots, was recently published in *Tropical Agriculturist*([3]) by the above officer, and indicates that proper attention is being paid to the accurate comparison of the strains before recommending them to the public. A matter of general interest in the report of the Entomologist, is his account of his work on the 'Eye Fly' (*Siphunculina funicola*), one of the mysteries of the tropics. As was the case in former investigations in Madras, this insect can be reared in many decomposing organic substances, but no success has yet attended the search for its actual breeding places, and they still remain undiscovered. Apart from the intolerable annoyance it causes, the Eye Fly is undoubtedly responsible for much ophthalmia and other eye troubles.

A development which has proved successful is the establishment of small nursery supply stations, from which the peasant cultivator can obtain stocks of seeds and cuttings. These have been popular, and their number is to be increased. Increasing attention is being paid to the use of cattle for tillage operations: a small herd of a well known working type breed has been imported from Madras, while in another direction an interesting series of drawbar-pull experiments have been carried out to test the efficiency of various types of ploughs.

We gather that the Year Book of the Department is no longer to be published, and there has been a reversion to the earlier and perhaps less satisfactory system of separate reports from the Technical and Divisional Officers, which are largely filled with administrative details of little interest to anyone save the Director. The present reports give a good account of the many activities of one of the foremost of the Empire's Agricultural Departments, and are therefore full of interest.

In conclusion, the reviewer is again glad to note that the practice of *asweddumizing* (Report Divisional Officers p. 4) still continues.

(1) Madras Department: Report of the Deputy Director, VII *Circle*: 1927: p. 192.
(2) *The Tropical Agriculturist*, Vol. LXVII, No. 3.
(3) *The Tropical Agriculturist*, Vol. LXVII, p. 272.

TROPICAL WORLD NOTES.

Nyasaland.

According to the Report of the Department of Agriculture, the oustanding change revealed by the agricultural statistics for 1927 is the reduction in the past ten years in the cultivation of cotton and the expansion in the acreage planted with tobacco. A marked increase in the acreage under tea and sisal is also recorded. The falling off in the production of native cotton is attributed in a large measure to disappointment in the prices paid in the previous year. Mental satisfaction at the reward that he receives for his trouble rather than economic pressure would appear to govern the Native in his decision to grow export crops. European production has also shown a considerable decline and is particularly regrettable in view of the urgent need for alternative crops to tobacco. Apart from the question of insect attack and concomittant low yields, the European is severely handicapped in planting large acreages of cotton on an individual estate owing to the difficulty of securing an adequate labour force at planting time (when it is most important that advantage should be taken of favourable spells of rainfall), as well as by the scarcity of labour at harvesting time in areas where Natives grow cotton on their own. But there is no reason why cotton should not be grown more extensively in rotation with tobacco at mid-elevations in the Protectorate. The success of the variety Over-The-Top imported by the Empire Cotton Growing Corporation has led to considerable interest being shown by planters in cotton for rotation purposes, and small plots are now being tried on a number of estates where cotton was not grown before or where its cultivation had been abandoned.

The tobacco industry in Nyasaland has progressed very much during the last 7 years. In 1913 the total amount exported was 3,763,014lb., most of which was flue-cured and two-thirds of which was of pipe grades. In 1921 the total amount produced was 4,000 cwts. by Natives and 60,148 cwts. by Europeans, a total of over seven million pounds. The production has risen in 1927 on the one hand to 69,680 cwts., nearly all dark-fired tobacco grown by Natives, and on the other to 93,647 cwts. of European flue and fire-cured and air-cured tobacco. The total exports in 1927 exceeded fifteen million pounds. Nyasaland tobacco has become increasingly popular on the U.K. market, and the slump which occurred early in 1927 is regrettable, especially as a large preferential duty still exists for Empire tobacco. Numerous types of tobacco are produced from the varying soil and climatic conditions of Nyasaland and some types are the counter-part of American growths. The growth of the latter in the field cannot be distinguished, there is a similar time taken in ripening and the methods of curing are identical. The yield, also, of tobacco per acre grown by the true-bill planter are similar to those produced by Virginians or Kentuckians growing similar types and varieties.

There has been a steady increase in the acreage planted with tea and the area under this crop amounted to 7,070 acres in 1927. The prospects of the industry continue to be promising, and improved methods of cultivation and manufacture have with good results followed the profitable prices obtained in recent years.

In 1927, there were 6,282 acres under sisal as compared with 6,212 acres in 1926, and 988 acres in 1917. This crop is one of the least dependent on a regular rainfall and has the added advantage that it is comparatively free of pests and diseases.

* * *

Bihār.

In Bihār the first sugar-cane is cut on the eleventh of the bright half of the month Kārtik (October-November, the bright half being the first half), when Vishnu wakes from his four months' sleep. Some people fasten a few canes together, place a neck ring on top, pour perfumes over the bundle, and then, removing the ring, proceed to cut the canes. It is scarcely necessary to point out that this is an act of worship of an effigy of a deity analogous to the "corn maiden." The Chāmars of the United Provinces perform the Gāyās rite at the cutting of the cane. Stalks of the cane are bound together and a pot placed below which is quickly filled with water in the hope that the cane may be abundantly filled with sap. A fire sacrifice is made and men walk quickly round the field a number of times. A few canes are broken off, and after these have been offered on an altar or placed on a bed with an axe, shovel, or sickle, and covered with a new cloth, a fire sacrifice is made and the canes are distributed among friends.—(*Nature*, Vol. 122, No. 3075.)

* * *

Brunei.

The State of Brunei, according to Colonial Report, No. 1394, is situated between British North Borneo and Sarawak, and is 770 nautical miles from Singapore. The value of the chief imports and exports was approximately $2,862,218 as against $3,276,573 in 1926, the decline being more than accounted for by the lower prices prevailing during the year for plantation rubber. The chief exports are pigs, kajang, cutch (extracts of bark), plantation rubber and sago flour. The pig-breeding industry is particularly flourishing, the pigs being exported to Miyi and Sarawak. The planting of rubber appears to have obsessed the natives to the exclusion of every other form of cultivation except their annual crop of rice. This was much below the average in 1927 owing to very heavy rains which occurred throughout the season.

Kenya.

Reviewing the trade situation in Kenya Colony in his speech at the opening of the Legislative Council in Nairobi, Sir Edward Grigg, the Governor, said that the Colony's exports in 1927 increased by 27 per cent. over those of 1926, and that he found from the Customs returns for the period ended September last that there had been a further increase of 10 per cent. in 1928 over the corresponding months of 1927. There had been large increases in the exports of wheat, wheat meal, flour, coffee, hides, wool, and carbonate of soda. In the first nine months of 1927, 120,000 cwts. of coffee were exported, but in the corresponding period of 1928, 161,000 cwts. were exported. There had been unfortunate decreases in the exports of maize and sisal.

Turning to the prospects for 1929, the Governor said that careful crop estimates had been formed by the Director of Agriculture based upon 178 returns from different farmers in the settled areas. Maize appeared to be poor in some of the chief producing areas especially in Lower Molo, Rongai, and Solai, but the shortage there had been compensated by very good crops in the Trans-Nzoia and Uasin Gishu, and an increase for export appeared to be reasonably certain. With regard to coffee, the crop for export in the early part of 1929 would undoubtedly show a considerable reduction, but there was a chance that the shortage would be compensated in full or to some extent in the latter part of the year. There would be a considerable increase in sisal, and with regard to native reserves, there were ample food crops except in some areas on the coast and in Kerio. There would undoubtedly be a considerable increase in grain for export from the native reserves. These estimates, the Governor added, might be fairly said to dispel the anticipation of any grave set-back in the development of Kenya Colony owing to the drought of the current year, always provided that the rains in 1929 were satisfactory.—(*Times Trade and Engineering Supplement*, Vol. XXIII, No. 546. 22nd December, 1928.)

* * *

Sierra Leone.

In the course of his annual address on the occasion of the opening of the 1928-29 Session of the Sierra Leone Legislative Council, His Excellency the Governor, Brigadier-General Sir Joseph Byrne, K.C.M.G., K.B.E., C.B., referred to the trade of the Colony during 1927. In the face of very moderate prices there were appreciable increases in the quantity of the chief products exported by Sierra Leone. Palm kernels were shipped to the amount of 65,426 tons, valued at £1,077,450, which was the largest quantity shipped from the colony in any year. Figures for the first eight months of 1928 show a further increase, for 51,178 tons were exported, which was 12 per cent. more than in the corresponding period of 1927. Shipments of palm oil in 1927 totalled 3,609 tons, but for 1928 there was a fall of 653 tons for the first eight months of the year. Kola nuts, which are consumed in West Africa generally, also enter largely into the export trade of Sierra Leone, and items of interest to British importers are ginger, which was exported to the extent of 27,354 cwt. in 1927; piassava, shipments of which totalled 2,418 tons; and cocoa, which amounted to 77 tons.—(*The Chamber of Commerce Journal*, Vol. LVII, No. 777.)

* * *

Leeward and Windward Islands.

The following information is abstracted from recent Reports received from the various Departments of Agriculture.

Montserrat.

An important and valuable importation of several varieties of budded Citrus plants was made through the Department from the Winter Haven Nurseries, Florida. These include grapefruit, oranges, tangerines, manderines and lemons. A collection of this group was planted out at the Station in the old site occupied by lime plots destroyed by the storm. The planting of suitable wind belts was also given attention. The budding of Citrus on Sour Orange Stocks has been continued. The 1928 cotton crop has so far yielded 600,000 lb. lint which have been shipped. The quality of staple received an exceptionally good report from brokers in Manchester. The percentage of stains in the whole island's crop worked out at only 4 per cent. On the whole high yields per acre were recorded throughout the island. The Pink Boll Worm gave no trouble and caused only a negligible amount of damage to the island's crop. Cotton sales have been much quicker and prices better than those of recent years.

Nevis.

The cane crop has made rapid progress owing to favourable rains, but the crop on the whole is still backward, and will be difficult to reap as the machinery damaged in the hurricane is not likely to be put back in time. Preparation and planting of the next crop is also in progress.

A good cotton crop is expected. On account of the hurricane the local Government made a free gift of two tons of first class cotton seed, which was distributed to the small growers, and was of very great assistance to them. There are about 1,400 acres planted in cotton, more than half of which is grown by the small growers.

St. Kitts.

The weather conditions during the month were very favourable and the old cane crop continues to make good growth. The condition of the crop has improved considerably since the hurricane and prospects are somewhat brighter. The crop is estimated at from 14,000 to 16,000 tons of sugar, but it will depend to a considerable extent on the quality of the juice at the time of reaping.

BUDDED RUBBER.

The Budding of Hevea in Modern Plantation Practice. By F. Summers. Published by the Rubber Research Institute of Malaya, September, 1928.

Rubber being one of the youngest of our major tropical crops, affords an interesting epitome of the evolution of agricultural practice and experimentation. In the earliest stages of its cultivation experimental work was directed towards the discovery of the best methods of establishing the trees, and next to the means of obtaining the maximum yield from them. A mycological phase followed, as diseases began to attack the plantations, and finally attention came to be given to the genetic constitution of the crop.

It was then found that on the average estate a considerable proportion of the trees did not produce enough rubber to pay for their cultivation, whilst on the other hand a certain number were better producers than the average, so that roughly thirty per cent. of the crop was being drawn from only ten per cent. of the trees. These figures were approximately the same in several different countries, and it was further established that the high yielders were relatively high in all seasons and the low yielders low in all seasons.

The question of improving the general average by increasing the proportion of high yielders thus came to the fore, but only so recently as about 1918, so that it must be borne in mind that attempts at genetic improvement of rubber are only ten years old, and the history of budded rubber is as yet only the history of the last decade.

Seed selection, the most obvious means of crop improvement, is slow work with any tree crop, and in the case of rubber, where the flowers are not easily accessible, and self-sterility appears to be the rule, it is particularly tedious and difficult. Vegetative propagation, on the other hand, has been used with certain tree crops for centuries with success, and can usually be depended upon to give uniform progeny. Its adoption on an experimental scale was therefore the logical line of attack on the problem, and it stands chiefly to the credit of Dutch scientific officers in the Netherlands East Indies that at the present time the pioneer work is over, and the budding of rubber is accepted as a regular plantation practice of proved usefulness.

Dr. Summers has distilled the essence from 40 publications on the subject (31 of which are Dutch), with the avowed intention of enabling the rubber planter "to form his own judgment of the position of the method in modern plantation practice."

Half of his 100 page manual is devoted to the history of the introduction and development of the method in Java, Sumatra, Malaya and Ceylon, and the other half to practical details of the method itself in all its varied aspects, such as selection of budwood and of stocks, the actual budding operation (including costs), after-treatment and care of buddings, multiplication nurseries, and test tappings.

Finally he gives his opinion of the future of budding, which he thinks "has not yet been developed to meet a tithe of the demands that the planter may make of it." The interesting point is made that many of the best Sumatra clones* have originated from mother trees raised from Malayan seed, which means not only that Malaya has every chance of finding clones as good as any in the Netherlands East Indies, but also that "there is no evidence against the existence in Malaya and Ceylon of clones yielding far more highly than those which are regarded to-day as first class."

It has to be borne in mind that the experimental work to date has shown that not every high-yielding tree will furnish a high-yielding clone. Indeed, according to Dias and Bertrand (*Trop. Agriculturist*, 1926), not ten per cent. of the mother trees produce satisfactory budded offspring.

The only test of a clone is therefore a tapping test, but it is now possible to obtain a fair knowledge of the worth of a clone by tapping about 20 trees for a short period in the fourth year, so that promising clones can be multiplied after that time, and when in the fifth or sixth years a more extended test has given the true annual yield of the clone, abundant budwood is available.

A systematic examination along these lines of all remaining high-yielding trees of the first and second generations of those originally introduced to the East is called for, in order that the very best clones available may be isolated.

So long as considerable improvement can be effected along the lines already laid down, work must be concentrated there, but it may be predicted that the next phase of experiment in Hevea propagation will concern the interactions of stock and scion, with special reference to the stock. The figures published show the members of a clone to be much more uniform than an equal number of seedlings, even from selected seed, but at the same time they seem to vary among themselves quite markedly. It may well be that this variability is introduced by the seedling stocks, and that optimum yields will only be obtained finally when clonal stocks of proved merit are available, as well as clonal scions.

At any rate the progress made in the last ten years, and the present position, as outlined by Dr. Summers, indicate clearly that still further substantial developments are likely to occur in the course of the next decade.

E. E. C.

*A "clone" means all the individuals propagated vegetatively from a single mother tree.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Further uses for Cottonseed Bran and Peanut Shells.

Both cottonseed bran and peanut shells are waste products of which disposal is difficult. Both are obtained in large quantities at the oil presses and thus the cost of collection is borne by the main oil products. As raw materials, therefore, these substances have an advantage over corn stalks which are collected separately from the field, and the expense thus incurred is borne by the final by-product. At present a small amount of cottonseed bran is used as filler for cattle feed, while peanut shells are used only for fuel or for fertiliser.

Workers at the American Bureau of Standards have analysed both materials and found that the former contains 40 per cent. and the latter 17 per cent. of substances giving reactions for xylose. In a process developed by Dr. Acree, both raw materials are hydrolysed with boiling dilute nitric acid. A mixture of xylose and other substances is obtained. If this mixture is concentrated, more nitric acid added, and the heating continued, the sugars are oxidised to their corresponding acids. If hydrochloric acid be substituted for nitric acid, furfural becomes the final product.

Commercial uses for these substances are suggested. Xylose may perhaps be utilised as a sweetening agent in the diet of diabetic patients. It is possible that xylose may be substituted for glucose in the spinning of artificial silk and in the weighting of leather.

More importance is attached to the uses of the mixed acids obtained by the oxidation of the sugars. The chief acid in the mixture is xylotrihydroxyglutaric acid, a dibasic, reducing acid with properties similar to those of tartaric acid. Its flavour is such that it makes good synthetic lemonade. It is suggested that it may replace the mixture of lactic acid and acetic acids now used in tanning. It can be used as a reducing agent in the chroming of wool and as the acid in the subsequent dyeing operation. Since for these processes, the acids do not require purification, the cost of production may be less than that required for competition with tartaric, lactic, citric, malic and other similar acids.

The residue obtained after the extraction of the xylose contains a considerable quantity of alpha-cellulose. If the hydrolysis is stopped before decomposition of the cellulose begins and rather before the maximum amount of sugar is obtained, the residual cellulose is suitable for the manufacture of paper and artificial silk.

Four products can thus be obtained from both these waste substances, each of which by slightly altering the manufacturing process, may be made the main product according to the state of the market. The determining factor for the success of the process is the cost of production. It is believed that these substances can be manufactured in large quantities to compete with the materials at present used.—(*Ind. and Eng. Chem. News Ed.* 6, 21, 3.)

* * *

A New Fibre.

A new fibre which can be used as a substitute for cotton is coming into prominence in the textile industry. The plant from which the fibre is obtained was discovered in British Guiana and taken to England. It is being grown successfully, attaining the height of seven feet on some of the poorest soils of the eastern counties of England.

The fibre promises to be equal in quality to coarse cotton. It can be treated by the existing cotton machinery and blended with silk, artificial silk and wool. It can be easily dyed, requiring a third less quantity of dye than cotton. Moreover, it is being sold at fourpence a pound less than the current price of cotton. A production of between three and four million pounds is promised for this year.

Whether this new fibre will fulfil its promise when produced and used in large quantities, and whether the production can be increased sufficiently to replace cotton entirely is an open question.

* * *

Paper Pulp from Begasse.

The usual method of producing cellulose from straw, grass and begasse gives material which has short, weak fibres only suitable for addition to other kinds of cellulose. A Swedish chemist, E. L. Rinman has recently patented a method whereby cellulose suitable for the manufacture of such types of paper as parchment paper, greaseproof paper, kraft paper and newspaper can be manufactured directly from these raw materials. The new process avoids the removal during the cooking and washing of the glutinous substances contained in the raw material. These substances serve as useful binders in making the paper. The raw material, if straw or grass, is cut into chaff and any dust removed. The chaff is cooked with caustic soda solution under pressure, with carefully controlled conditions, in a digester which keeps the liquid constantly circulating. After three hours, the mass is removed and diluted with cold used liquor. It is then filtered, washed with more cold liquor and then with water. Finally it is ground to a suitable fineness. The product may be bleached with the normal bleaching substances at a low temperature.—(*Ind. and Eng. Chem. News Ed.* 6, 10, 6.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

The pH of Sugar Media and their Power of Inversion.

The Abbe Colin, speaking on the subject before the French Association of Sugar Chemists (*Bulletin*, Oct., 1928), says that, after considerable interest in the matter, the scientific world commences to realise that measurements taken have not always been correct, and do not justify all conclusions drawn. The electrometric determinations are exact, but the colorimetric methods are easier; however, it is well known that the information given by several indicators on the alkalinity or acidity of a medium are far from identical. Boric acid and carbonic acid are neutral to helianthine, but acid to phthalein; in neutralising with soda a phosphoric acid solution with methyl orange or with phthalein, different phenomena are observed, and the turning points of the different indicators become important. Most of the physical, chemical and biological phenomena in relation to acidity and alkalinity depend on the pH of the medium. In regard to flocculation, absorption, filtration, hydrolysis, weak variations in pH may have considerable effects. Sweet fruits are often found to contain sucrose, while the acidity of the juice is often high; still no inversion occurs, and some juices can stand a certain heat, because the free acids are in presence of their lime and potash salts that affect their hydrolytic power. It has been also observed that the same colloid can coagulate at different pH points, according to the nature of the substances present: Thus the flocculation of beet diffusion liquors can be brought about either at about five pH or at about 11 pH. Such relations of pH of different sugar factory products, as are given by Barbaudy and others, are constantly subject to revision, since the first material is never the same. The measurement of the pH in sugar factories cannot greatly change sugar technology, it is by a better insight into the subjects, of flocculation, absorbtion, filtration, and hydrolytic phenomena, that present methods will be improved.

Inversion is one of the most important problems in sugar technology. It was at first thought that sucrose hydrolysis by acids follow very simple laws; or that the concentration of hydrogen ions gave the exact measure of the hydrolytic power; but subsequent studies have clearly shown that this is not the case. This makes it impossible to definitely answer as to the extent of the danger of hydrolysis in sugar media, of different given values. This leads us to the question whether it is convenient, as many affirm, that juices sent to the evaporators be kept clearly alkaline during all the time that the evaporation lasts, in such a way that the tail products (massecuite, molasses) may show a slight alkalinity to phenolphthalein. Why have juices at 9 or 10 pH, when 7 pH is sufficient for avoiding hydrolysis of sucrose? And, again: is it preferable to have a small amount of reducing sugars but no lime salts, a medium favourable to grain formation and growth, and therefore less molasses, or the contrary? While the answer seems obvious, still it cannot be accepted as a system or rule. The treatment that is best for juices of high purity, containing but traces of invert sugar is not the most suitable for juices of different purity and composition. Under such circumstances how is it possible to state, once for all, the amount of alkalinity that should be left in juices entering the evaporators? Here, Colin admits, empirical practice is the only one possible at present, but empirism eager to know and verify new data.—(*Sugar*, Vol. XXXI, Nr. 1, p. 10.)

* * *

Rapid Sand Filtration of Sulphitation Thick Juice.

G. J. T. Heyning in *Java Archief*, Vol. XXXVI (1928), pp. 1179-1182 describes a rapid sand filter for thick juice installed by him at the Dinoyo factory by means of which a bright thick juice was easily obtained.

The apparatus consists of a pressure drum for the thick juice by means of which the filter can be put under a light pressure. The filter contains a layer of sand about one meter deep; the granulation found to be most suitable was about two millimeters; when the granulation of the sand was about one millimeter the capacity of the filter was too small.

The filter is prepared for use by passing thin juice through the sand from below upward, so as to displace the air. The thick juice is then let in from above and passes out below. The filter remains in operation about four hours before the lessened rate of filtration indicates need of cleaning. The accumulated solids are removed by introducing thin juice from below, accompanied by compressed air, just as an ordinary sand filter in waterworks is washed. The thin juice used for washing is returned to the sulphured thin juice. Any sand that passes over during washing is caught on a sieve.

The effectiveness of the filtration was investigated by an expert from the Pasoeroean station. The suspended matter content of the thick juice coming from the evaporators was determined by means of a De Laval supercentrifuge before and after passing the sand filter. The two values thus found were respectively 0.029 and 0.005 per cent. showing that the matter in suspension was reduced to about 17 per cent. of the original amount. The capacity of the filter is about 70 hectoliters of thick juice per hour per square meter of filtering surface. About 15 minutes are required for washing out the filter. A sulphitation factory grinding 1,000 tons a day could do very well with three filters, each about one meter in diameter.—(*Facts About Sugar*, Vol. XXIV, No. 2, p. 34.)

WEST INDIAN GRAPEFRUIT.

Figure 6.—A young grapefruit tree that was not trained and formed a head too low. Compare with Fig. 7.

Figure 7.—A young grapefruit tree with a good head. Compare with Fig. 6.—Photo taken in Trinidad.

Figure 8.—Collar rot on seedlings or low budded grapefruit in British Honduras.

WEST INDIAN GRAPEFRUIT.

Figure 9.—A mature grapefruit tree of good size and shape. It is probably about 20 years old.—Photo taken in Florida.

Figure 10.—A well-grown, five-year Marsh grapefruit, showing a good type of growth.—Photo taken in Florida.

REVIEWS.

GUIDE TO THE LIBRARIES OF LONDON. R. A. Rye. *University of London Press, Ltd.*, pp. 580.

This is the third edition of a well known reference book, in which Mr. Rye provides for research students and the reading public a detailed guide to the many libraries in London, with practical information on their contents, and particulars as to the conditions of admission, borrowing privileges, hours of opening and other essential details. His book is not only a catalogue of existing facilities, but contains also useful and interesting descriptions of the most important special collections, as well as historical notes on their formation, and references to their outstanding bibliographical treasures. The British tropics teem with most interesting problems, but it is rare that anyone is able to pursue them in a scholarly fashion. Natural conditions are neither inducive to study nor to the maintenance of books. With a guide like that of Mr. Rye those disposed to study and work up their material when on leave or in retirement are well served. Some of the special libraries described in Chapter V might be of particular interest. One section deals with British Overseas Dominions, Colonies, Protectorates and India. The British North Borneo Company, the Ceylon Association, the East India Association and the West India Committee have collections on their own spheres of influence. The Libraries of the Imperial Institute and the Royal Colonial Institute are important. The first gives special attention to publications relating to tropical agriculture and forestry, mineral resource, the languages of India, America, Africa, Polynesia and other parts of the world. The second contains over 184,000 volumes and pamphlets relating to the history, government, economics, resources and development of the oversea portions of the British Empire including India and the problems of colonisation and administration generally.

Apart from its intrinsic value, the book is extremely well produced; the paper, type and arrangement are pleasing, and the illustrations are excellent.

G. W.

* * *

TRADE INFORMATION BULLETIN. No. 273. Quinine—Production and Marketing—by Samuel H. Cross. Bureau of Foreign and Domestic Commerce. Pages 50.

This is the best publication the writer has seen on the economic questions connected with the production of cinchona bark. The development of the Dutch monopoly is traced in some detail. Chapters are also included on the extent and methods of culture in Netherlands East Indies and on British efforts at independent production. The bulletin was written in 1923 and it is stated that "It is . . . not clear that the control of the Dutch monopoly has so far been in any way harmful to the general interest, so that efforts to break it down can be based only on ambitions for national self sufficiency." Since that date the position appears to have changed. High prices have caused decreased consumption and regarding this as undesirable, the Health Committee of the League of Nations determined in 1926 to take all steps to break the monopoly, while countries subject to malaria began to take action on their own account. The last quinine agreement was subject to revision in December, 1928, and by the time this review is published it should be clear whether the position has been altered.

* * *

THE SCIENTIFIC PRINCIPLES OF PLANT PROTECTION. By Hubert Martin. *Edward Arnold & Co.*, London, 1928. pp. 316. Price 21s.

In this volume the author has surveyed all the weapons at the disposal of Plant Pathologists and Entomologists in fighting the diseases and pests of plants. The various methods of control are classified under different headings, described briefly in tabular form in the introduction, and treated at length in the subsequent chapters. The general plan of the book is good, each section of the several chapters being followed by a list of references. The contents of the chapters are briefly but adequately described, and an author and a subject index is also given. The reader can, therefore, become familiar with the book almost immediately.

The book will be found very useful by teachers, students, and research workers in Plant Pathology and Entomology, since it not only deals with all the available means of disease and pest control but suggests various lines of future research.

When applied to conditions in tropical countries, however, it is felt that too large a section of the book is taken up in the consideration of Fungicides and Insecticides as compared with the more important means of control dismissed in the fourteen pages of Chapter III which deals with "The influence of external factors on the susceptibility and liability of the plant to attack."

H. R. B-J.

* * *

REPORT OF THE ROYAL COMMISSION ON INDIAN CURRENCY AND FINANCE, VOL. I, His Majesty's Stationery Office. Pages 144.

Questions of currency and banking are very important in their reverberations on agriculture and the agricultural population. Indian problems have become classic and their history cannot fail to be a guide in some of the colonies where currency problems are beginning to emerge. The above report deals with the currency system, the questions of a gold standard, a central bank and the stabilisation of the rupee.

G. W.

COLLEGE NEWS.

Sir Otto and Lady Beit and party visited the College on 31st January and were shown round by the Principal and the Professor of Botany.

* * *

Professor T. B. Wood, C.B.E., F.R.S., F.I.C., member of the Governing Body and Mrs. Wood arrived from England by the s.s. *Ariguani* on the 9th February.

* * *

We regret to state that Dr. E. J. Maskell was unable, through illness, to conclude his article on "Experimental Error" for this issue of *Tropical Agriculture*.

* * *

Dr. Laurence P. McGuire, Plant Physiologist for Banana Research under the Empire Marketing Board, returned from Central America by the s.s. *Bayano* on 8th February.

* * *

A meeting of the Trinidad Science Club was held on 31st January, when Dr. J. G. Myers, M.Sc. (N.Z.), Sc.D. (Harvard), gave a lecture on "Control of Parasites by Biological Methods."

* * *

The Duke and Duchess of Devonshire, Lady Anne Cavendish and Miss M. Morrison were entertained by the Principal and Mrs. Evans and visited the College on 31st January.

* * *

Captain Leatham, R.N. and Mrs. Leatham were entertained by the Principal and Mrs. Evans on 8th February, and other officers of H.M.S. *Durban* paid frequent visits to the College during the stay of the ship in Trinidad.

* * *

The Principal sailed by the s.s. *Stuyvessant* on 19th January for Barbados where he attended the West Indian Standing Conference at the invitation of the Secretary of State for the Colonies. He returned by the s.s. *Asturias* on 31st January.

* * *

Mr. René Gide, the New York Joint Manager of the N.V. Potash Export Co. of Amsterdam, Holland, visited the College recently and was good enough to offer to the Institution two tons of Muriate of Potash 50% K_2O and two tons Sulphate of Potash. The offer has been gratefully accepted.

* * *

Mr. G. Huxley, M.C. of the Empire Marketing Board, who sailed for England by the s.s. *Bayano* on 8th February spent several days at the College where he was given the opportunity of getting into touch with its activities. Mr. Huxley, during his stay, was the guest of the Principal and Mrs. Evans.

Mr. S. F. Ashby, who was Professor of Mycology and Bacteriology at the College from 1922-26 and who is now Mycologist at the Imperial Bureau of Mycology, Kew, visited the College on 28th January. Mr. Ashby was on his way to Dominica, Montserrat and Antigua where he will, in the course of the next six weeks, investigate various lime diseases.

* * *

Mr. Karl Walter, Secretary of the Horace Plunkett Foundation, and Mrs. Walter, arrived in Trinidad by s.s. *Cavina* on 26th January, and visited the College during their stay as guests of the Principal and Mrs. Evans. Mr. Walter is touring the British West Indies under the auspices of the Empire Marketing Board with a view to studying the development of the possibilities of co-operation. He is expected to return to Trinidad on 26th February.

* * *

At a meeting of the Academic Board on 18th January, the following students were awarded the Associateship of the Imperial College of Tropical Agriculture.

Mr. J. B. Hutchinson, B.A. (Cantab.), Empire Cotton-Growing Corporation student in 1924-25 and Assistant Geneticist, Cotton Research Station, Trinidad.

Mr. W. Allan, B.Sc. (Glasgow), Empire Cotton-Growing Corporation student in 1927-28 and Entomological Officer, Government Agricultural Experiment Station, Mazabuka, Northern Rhodesia.

* * *

The College has recently received through the kindness of Sir William Himbury, of the British Cotton-Growing Association, and the interest of the Fine Spinners' and Doublers' Association, who were responsible for its preparation, an excellent show case of cotton samples for lecture and demonstration purposes. The case which is beautifully made and fitted, gives a complete range of lap, slivers, rovings and cops, and samples of the waste obtained in the preparation of each. There are also specimens of various kinds of cloth, and the yarns actually used in making them. All the specimens are arranged to be easily detachable for examination and class demonstration. The case forms a very valuable acquisition to the teaching facilities of the College, and our thanks are due to those who have so kindly obtained it for us.

* * *

Among other visitors to the College were: Rear Admiral Alan Hotham; Mr. Walter Heape, F.R.S., Colonel and Mrs. A. B. Acland and Mr. and Mrs. Alfred Wigglesworth. Mr. Wigglesworth is Chairman of the Vegetable Fibres Committee of the Imperial Institute and on the Executive Council of the Joint East African Board and has

large interests in sisal plantations in East Africa; the Hon. Sir James Aikens, K.C., LL.D., formerly Lieutenant-Governor of Manitoba, Professor E. Huntington, Yale University; Dr. H. Holmes Orr; Sir Edward Davson, Bart., and Lady Davson. Sir Edward Davson is a Governor of the College and was Chairman of the British West Indies Standing Conference which met recently in Barbados; Mr. R. R. Sedgwick, Secretary of the same Conference; Messrs. Henniker Heaton, Hand, and Spurling of Bermuda and Messrs. Douglas Jones and Smellie of British Guiana, delegates in the above Conference. The Jamaica delegates Messrs. Nash, Barton, Wint and Mr. and Mrs. Sangster also visited the College with the particular object of seeing the banana research work in progress and were conducted round the experimental areas and laboratories by Professor E. E. Cheesman and Dr. C. Wardlaw.

SIR JAMES CURRIE'S VISIT.

Sir James Currie, K.B.E., C.M.G., Chairman of the College Governing Body arrived in Trinidad by the s.s. *Asturias* on 31st January. He was accompanied by the Principal and Mr. G. Huxley, M.C., of the Empire Marketing Board, who were present with him at the West Indian Standing Conference. Sir James has made his headquarters at the College where he is the guest of the Principal and Mrs. Evans. It is too early yet to give a detailed account of his visit which is expected to last for about three weeks. His time, so far, has mainly been confined to inspecting the various College Departments and their activities and to discussing future developments and present needs with those in charge. Sir James gave an address to the College on 8th February on "The career of an agricultural officer in the Tropics." We should like to take this opportunity of congratulating him on his being made a member of an Advisory Committee which has recently been appointed by the Secretary of State for the Colonies to advise on problems of educational development in the Colonies not possessing responsible Government, the Protectorates and Mandate Territories.

AGRICULTURAL EXCURSIONS.

By the courtesy of their owners, three coconut estates, Concord and Plaisance, the properties of Tennant & Co., Ltd., and Plein Palais, the property of Trinidad Leaseholds, Ltd., were visited on 16th January. The party was first conducted round a section of the Concord Estate by Mr. J. Stanhope Lovell when an opportunity was taken to discuss the establishment and management of coconut plantations, and to witness the sun drying of copra and the methods used for breaking coconuts. The party then proceeded to the Plein Palais Estate where they were received by the Manager, Mr. McInroy, who had made elaborate preparations for the visit. Coconut palm trees in all stages of Bronze Leaf Disease were inspected and an account of the disease, illustrated by diagrams, was given by Dr. Briton-Jones. Demonstration holes had been dug on various parts of the estate to show the extreme variations in the soil and their effect on drainage, whilst palms in different stages of the disease were felled which made it possible to see the bacterial rotting of the bud developed late in the course of the disease. The party was also made familiar with existing systems of manuring and draining and with the processes involved in the artificial drying of copra. The excursion was much enjoyed by all those present and thanks are due, both to Mr. Stanhope Lovell and to Mr. McInroy for their kindness in showing the party round the estates.

The customary visit to the Empire Cotton-Growing Corporation's Experiment Station, was paid by the post-graduate students on 30th January, when Dr. Harland and Mr. Hutchinson explained the nature of the Station's work and gave the students an opportunity of seeing new types of cottons. There were two parties and while one was shown the greenhouses, the selection of types that the Station had accumulated, and something of the laboratory work, by Dr. Harland, the other, escorted by Mr. Hutchinson, learnt something of the field work. Our thanks are due to these two officers for the time they devoted to the demonstration and to the very instructive series of exhibits which they had prepared.

GIFT TO SUGAR FACTORY.

The College Factory was recently presented by Messrs. A. & W. Smith & Co., Ltd. of Glasgow with a Cast-iron Belt, 20 inches high, with fittings and lagging complete, designed to increase the capacity of the Vacuum Pan which they had originally presented to the College.

This valuable gift is the result of a visit from Mr. Ross, the firm's representative, to the College Factory early in 1928. This gentleman, whose visit was greatly appreciated, realized that, owing to the special conditions of operation of the plant, greater elasticity would be provided by increasing the cubic capacity of the Pan.

The Vacuum Pan now presents a very business-like appearance; and the College tenders thanks to Messrs. A. & W. Smith & Co. Ltd. for this useful presentation, and also for their continued interest in the welfare of the College Sugar Factory.

BIOLOGICAL EXCURSIONS.

A scheme has been formulated by which it is hoped to be able on future occasions to arrange biological excursions to various localities with a view to collecting their fauna and flora and taking photographs of the landscape, vegetation and other objects of interest. A record will be kept of the specimens collected and descriptive notes will be published from time to time in *Tropical Agriculture*.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—The Home Market has been mainly quiet and prices generally have shown an easier tendency; the course on the London Market having been as follows (*c.i.f.* per cwt.):

	Foreign.	*Preferential*
	s. d.	*s. d.*
7th January ..	9 9	13 6
22nd January ..	9 7½	13 4½
8th February ..	9 6	13 3
11th February ..	9 6	13 3

The recent low level of prices has encouraged a broader interest in the article and attracted some outside support, while distributions in the United Kingdom have taken on a little more confidence and a freer movement of refined is reported. *The Weekly Statistical Sugar Trade Journal* for 24th January states, "Sugar making in Cuba continues to go on very rapidly, our estimate of the production up to and including January 19th being 700,000 tons, while at this time last year sugar making had just about begun." With regard to the recent agitation for a single selling agency there appears to be a strong feeling in the island against any control or restriction. Beet sowings in Hungary and Italy in the coming season are expected to increase and the tendency amongst continental countries to protect the home industry from outside competition continues to develop.

* * *

COTTON.—*The Liverpool Circular*, 25th January, reports that a moderate business was done in African, Egyptian continued in moderate request and that rather more business had been done in Sea Island at steady prices.

* * *

COCOA.—Cocoa shipments from the Gold Coast for three months ending 31st December, 1928, amounted to 84,126 tons against 65,626 tons the previous year. Despite this increased output the market generally has been quietly steady, and as the Gold Coast season is now at an end indications rather tend towards higher prices. Whether this will be realised is difficult to say in view of continued large stocks available in warehouses in New York and the attitude of American manufacturers in using Exchange facilities to cover their requirements.

Trinidad shipments for the month of January amounted to 6,819,398 lb. against 5,397,881 lb. in 1928 and it is still too early to say how the crop will turn out. Weather conditions are all that could be desired and the prevailing rains are very acceptable.—(*By courtesy of the Cocoa Planters' Association, Trinidad.*)

* * *

COFFEE.—At the end of January good sorts were in demand but common to ordinary kinds were difficult of sale and irregular. At the opening auction of the year on 8th January a very firm market was experienced for new crop Costa Rica, both foreign and London cleaned, up to 165*s.* per cwt. being paid for parcels of London cleaned possessing good size and colour. The quality of the 4,774 bags of Kenya coffee offered was rather poor, and although strong prices were realised for good lots, the market at times was uncertain. About 3,600 bags Tanganyika chiefly sold at easier rates and Uganda was disposed of without any particular feature.

* * *

TEA.—In the auctions in the last week of January common kinds of Indian were weak and several lines sold as low as 1*s.* 1½*d.* Darjeelings were generally poor, but all those with flavour made satisfactory prices. The quality of Ceylon was not always on a level with previous offerings. Leaf descriptions sold at 1*s.* 2*d.* to 2*s.* 2¾*d.* Broken Pekoe 1*s.* 3½*d.* to 2*s.* 1*d.*, Broken Orange Pekoe 1*s.* 7*d.* to 2*s.* 3¾*d* per lb. A few Java and Sumatra Brokens sold as low as 11½*d.*, but Upper Broken Orange Pekoes fetched 2*s.* to 2*s.* 2*d.* and extra showy 3*s.* 5½*d.*

* * *

RUBBER.—The year started with a rather more active market, firmness being assisted by the improved statistical position, and in the week ending 16th January was witnessed the most active and exciting trading since April. A large volume of business was transacted, heavy buying by speculators being much in evidence. By the end of the month the market was quieter but still remained firm. Quotations for Plantation sheet have ranged as follows: 1st January, 8⅝*d.* 10th January 9⅛*d.*; 15th January, 10½*d.* 24th January 10¾*d.*; 2nd February 11d.

* * *

LIME PRODUCTS.—*Lime Oil:* Handpressed is firm and scarce and nominally worth 62*s.* 6*d.* per lb. Distilled is quiet but steady at 29*s.* to 30*s.* per lb. *Lime Juice* Concentrated is firm and unchanged. (Last price reported £25 12*s.* 6*d.* *c.i.f.*) *Raw* is quiet and unchanged. (*The West India Committee Circular* 24th January.)

* * *

BANANAS.—Jamaicas are unchanged at £25 per ton (delivered) to wholesalers and 1*s.* per dozen (carriage extra) to retailers. Brazilians are also only in fair demand, and the price is unaltered at £20 per ton, delivered nearest railway station. As is only to be expected, the consumption of bananas has been affected by the cold weather.—(*The West India Committee Circular* 24th January.)